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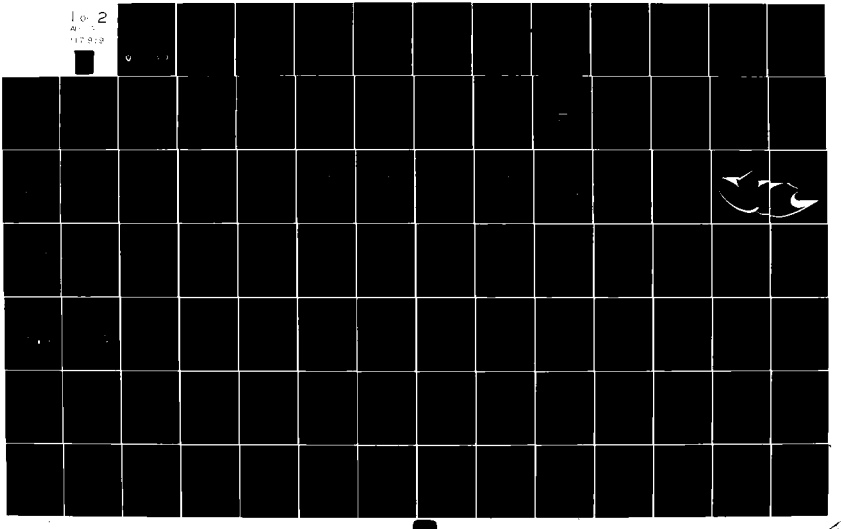

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AVRADCOM

Technical Report - 79-0270-4

NON-COMPLEX ITEM DEVELOPMENT SPECIFICATION FOR A FEASIBILITY MODEL OF AN ELECTRONIC MASTER MONITOR AND ADVISORY DISPLAY SYSTEM (EMMADS)

GENERAL ELECTRIC COMPANY
AIRCRAFT EQUIPMENT DIVISION
BINGHAMTON, NY 13902

JUNE 1981
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HISA-FM-981-78

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is a specification establishing the requirements, quality assurance provisions, and necessary delivery preparations for a feasibility model of an Electronic Master Monitor and Advisory Display System for a CH-47C helicopter.

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1.0 SCOPE.

This specification establishes the requirements, quality assurance provisions and necessary delivery preparations for a feasibility mode of an Electronic Master Monitor and Advisory Display System (EMMADS) for a CH-47C helicopter.

2.0 APPLICABLE DOCUMENTS.

2.1 Government Documents. The following documents of the exact issue shown form a part of this specification to the extent detailed herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall supersede all others.

SPECIFICATIONS:

Military

MIL-E-5400P 2 July 1973	Electronic Equipment, Airborne, General Specification for

STANDARDS:

Military

MIL-STD-129H 5 January 1980	Marking for Shipment and Storage
MIL-STD-490 (2) 18 May 1972	Military Standard Specification Practices
MIL-STD-1188A 3 January 1978	Commercial Packaging of Supplies and Equipment

MIL-STD-1553B (1) 12 February 80	Aircraft Internal Time Division Command/Response Multiplex Data Bus

Other

American Standard Code for Information Interchange (ASCII)

OTHER PUBLICATIONS:

Reports

ACS 12,217 June 1981	Electronic Master Monitor and Advisory Display System (EMMADS) - Operational Functions Report
ACS 12,262 (Rev 2) February 1981	Electronic Master Monitor and Advisory System (EMMADS) - Acceptance Test Procedure
ACS 12,385 October 1980	Electronic Master Monitor and Advisory Display System - Human Engineering Summary Report

2.2 Non-Government Documents. Following documents of the exact issue shown, form a part this specification to the extent detailed herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall supersede all others.

STANDARDS:

Electronic Industries Association

EIA RS-170 November 1957	Electrical Performance Standards - Monochrome Television Facilities

EIA RS-232-C
November 1978

Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange

3.0 REQUIREMENTS.

3.1 Item Definition. The Electronic Master Monitor and Advisory Display System (EMMADS) feasibility model shall be a non-flight-worthy system capable of demonstrating the concept of integrating helicopter subsystem parameter monitoring and warning/caution/advisory functions into a digital computer controlled display system. The parameters of concern to EMMADS are those normally scrutinized by the flight crew, via dedicated cockpit instruments and/or discrete indicators, to determine the status of the engine, fuel, power train, electrical, hydraulic and other miscellaneous helicopter subsystems. The helicopter to which the EMMADS feasibility model will be taylored is the CH-47C, equipped with T55-L-11D engines. The parameters currently available on that helicopter are tabulated in Appendix I.

The EMMADS feasibility model shall be capable of receiving simulated helicopter sensor signals over a dual redundant, MIL-STD-1553B digital data bus. The signal interface and data formating requirements shall be as defined in this specification.

3.1.1 System Diagram. A system block diagram showing the major functional partitioning of the EMMADS feasibility model is provided in Figure 1.

3.1.2 Major Components. The EMMADS feasibility model is composed of the following major components as depicted in Figure 1:

a. A thin film electroluminescent flat panel display unit (DU)

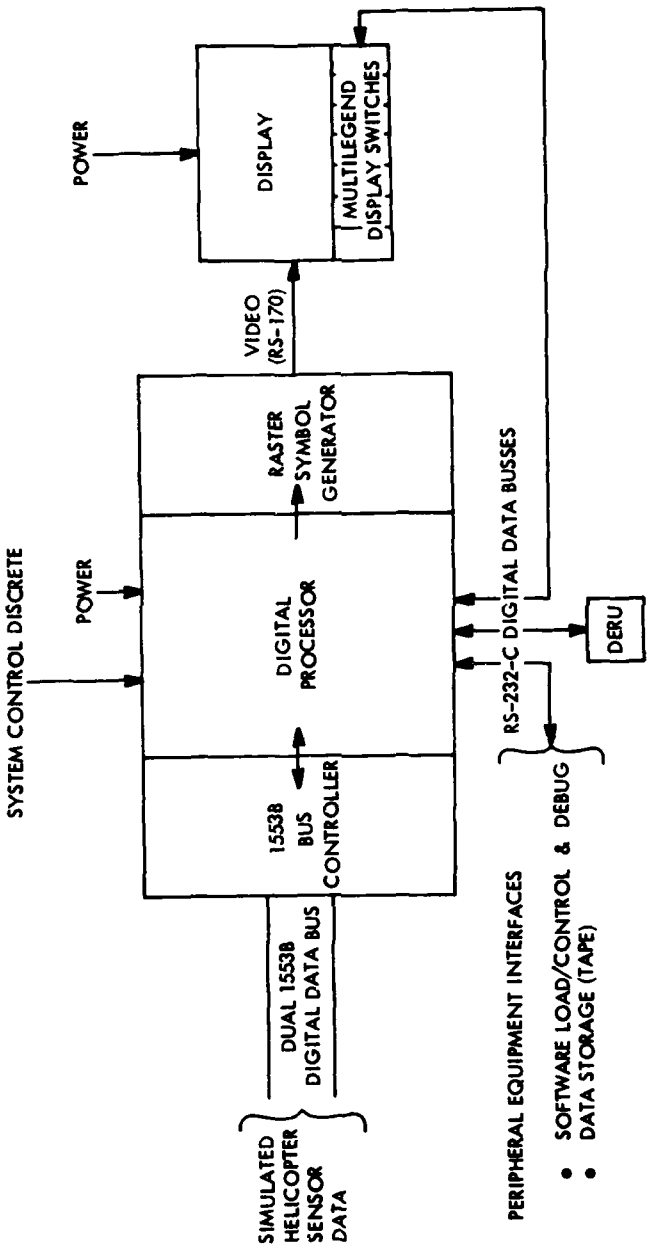


Figure 1. EMMADS Feasibility Model Functional Block Diagram

b. Seven programmable multilegend display switches (MLDS)

c. A data entry/retrieval unit (DERU)

d. A MIL-STD-1553B dual redundant digital data bus controller (DBC)

e. A digital processor (DP)

f. A raster symbol generator (RSG).

In addition, all digital data busses and the video signal connection shown in Figure 1 are considered to be part of th EMMADS feasibility model.

3.1.3 Interface Definition. The EMMADS feasibility model shall implement the signal interfaces defined in this specification.

3.1.3.1 Serial Digital Busses. The dual redundant serial digital interface over which EMMADS receives simulated helicopter sensor data shall conform to MIL-STD-1553. The serial interfaces between the DP and the DERU, MLDS and related periphal equipment shall conform to EIA RS-232-C standards. The interface to the MLDS shall provide busses for simultaneous transmission of switch actuation information from the MLDS to the DP and switch legend update information from the DP to the MLDS. Except as otherwise detailed in the Performance section of this specification, bus data traffic formating shall be at the discretion of the supplier.

3.1.3.2 Video Interface. The video interface between the RSG and the DU shall conform to EIA RS-170 TV standards and shall consist of a single cable terminated by 75 ohms in the DU.

3.1.3.3 BC/DP and RSG/DP Interface. The type of interface selected for the major components shall be left to the discretion of the supplier. The selection should be made on the basis of facilitating the operating characteristics of the EMMADS feasibility model, as defined in this specification.

3.1.3.4 System Control Discrete Interfaces. A hardwire discrete interface shall be provided to the DP for externally controlling processor operation to allow software program loading.

3.2 Characteristics.

3.2.1 Performance.

3.2.1.1 Major Components. The performance characteristics of the major components of the EMMADS feasibility model shall be as specified below.

3.2.1.1.1 Display Unit. The display unit shall utilize a thin film electroluminescent graphics panel. The display design criteria detailed in the EMMADS Human Enginering Summary Report shall be utilized as a guide in the areas of display luminance, uniformity, resolution/pixel size, contrast ratio, refresh rate and viewing angle. Character size, dot matrix and font shall represent the best compromise between the recommendations of the Human Engineering Summary Report and the capabilities of the available display hardware that best satisfies the other requirements of this specification. The display unit shall be capable of receiving and displaying composite video information formatted in accordance with EIA RS-170 TV standards. The display unit shall have an external control for varying display brightness, mounted on the front of the display unit.

3.2.1.1.2 Multilegend Switches. The EMMADS feasibility model shall utilize seven multilegend switches. They shall be located

directly below and in the same enclosure as the display panel. The switches shall display legends by utilizing LED dot matrix alphanumeric displays. The switch legend refresh and switch actuation encoding/transmission functions shall be contained in the display unit enclosure. Switch actuation code shall be transmitted to and decoded by the DP. The DP shall transmit to the MLDS updates of the switch legends, as appropriate. Transmission to and from the DP shall be via an RS-232-C bus pair, except up to two bus pairs may be utilized. The switch legend characters design criteria detailed in the EMMADS Human Engineering Summary Report shall be utilized as a guide in the areas of character luminance, uniformity, resolution/dot size, contrast ratio, refresh rate and viewing angle. Character size, dot matrix and font shall represent the best compromise between the recommendations of the Human Engineering Summary Report and the capabilities of the available MLDS hardware that best satisfies the other requirements of this specification. An external control shall be available on the display unit for varying switch legend brightness.

3.2.1.1.3 Data Entry/Retrieval Unit. The DERU shall be a hand-held control/display unit with internal memory. It shall have the capability of displaying alphanumerics entered through its key pad and of communication with the DP through a full duplex RS-232-C serial digital interface. The DERU shall also be capable of utilizing this DP communication link to transmit characters stored in the DERU memory. The DERU shall have an LED type display capable of displaying at least 24 ASCII type characters, using a 5 x 7 dot matrix. It shall be capable of one-hand operation and have the ability to store at least 150 characters.

3.2.1.1.4 Bus Controller. The EMMADS feasibility model shall contain a bus controller which shall have sole responsibility for information transfers on the MIL-STD-1553B type data bus. The bus

controller shall only be required to implement bus controller (BC) to remote terminal (RT) and RT to BC type operations. Normal operation shall be in the RT to BC mode. The BC shall be capable of requesting/accepting simulated helicopter sensor signal data according to the sequence shown in Table I and Table II.

This sequence shall repeat at a rate commensurate with the bus transmission rate of 1 megabit per second.

3.2.1.1.5 Digital Processor. The DP shall be capable of accepting and storing the data words as they are transmitted, according to the sequence shown in Table I. In addition, the DP shall be capable of interpreting the individual discretes within the packed discrete words (PDWD's) of Format 2, utilizing the PDWD breakdowns shown in Table II. The DP shall also perform computations on the data, as specified in 3.2.1.2.3.1, determine appropriate formats to be displayed and transmit the formats to the RSG. The required DP operating characteristics are summarized in Table III.

3.2.1.1.6 Raster Symbol Generator. The RSG shall accept data and display mode commands from the DP and convert them to the appropriate form for display imaging. The RSG shall have the capability of storing, in its own non-volatile, solid-state memory, all display formats required by 3.2.1.2.1. These formats shall be selectable by the DP. The RSG shall be configured to provide 525 line, 2:1 interlace, real time raster imagery at 30/60 frame/field rate, according to ETA RS-170 standards. It shall produce 480 active lines with 640 active elements on a line for a 4:3 aspect ratio. To maximize symbol capacity, two image buffers shall be used by the RSG in a "ping-pong" mode, i.e., one buffer is used to refresh the display while the other is being updated. Image buffers shall be updated (written into) by the DP. The required RSG operating characteristics are summarized in Table IV.

TABLE I

RT TO BC MESSAGE FORMATS

Format 1	Format 2 (PDWD = Packed Discrete Words)
Command Word	Command Word
Status Word	Status Word
Eng 1 TGT	(Reserved)
Eng 2 TGT	(Reserved)
Eng 1 Oil Pressure	Forward Cyclic Trim Actuator
Eng 2 Oil Pressure	Aft Cyclic Trim Actuator
Eng 1 Oil Temperature	Rotor RPM
Eng 2 Oil Temperature	(Reserved)
Eng 1 Xmsn Oil Pressure	(Reserved)
Eng 2 Xmsn Oil Pressure	(Reserved)
Combining Xmsn Oil Pressure	(Reserved)
Forward Xmsn Oil Pressure	(Reserved)
Aft Xmsn Oil Pressure	Generator 1 Load
Eng 1 Xmsn Oil Temperature	Generator 2 Load
Eng 2 Xmsn Oil Temperature	Rectifier 1 Load
Combining Xmsn Oil Temp	Rectifier 1 Load
Forward Xmsn Oil Temperature	PDWD1
Aft Xmsn Oil Temperature	PDWD2
#1 Hydraulic Pressure	PDWD3
#2 Hydraulis Pressure	PDWD4
Utility Hydraulic Pressure	
APU Accumulator Pressure	
Fuel Quantity-Left, Forward	
Fuel Quantity-Left, Main	
Fuel Quantity-Left, Aft	
Fuel Quantity-Right, Forward	
Fuel Quantity-Right, Main	
Fuel Quantity-Right, Aft	
Eng 1 N_1	
Eng 2 N1	
Eng 1 Torque	
Eng 2 Torque	
(Reserved)	
(Reserved)	

TABLE II

EXPANSION OF PDWD'S

(X = Don't Care; Bit 0 is LSB)

Bit#	PDWD1	PDWD2	PDWD3	PDWD4
0	Eng 1 Oil Low	0	X	0
1	Eng 2 Oil Low	0	X	0
2	Eng 1 Chip	Eng 1 Start Fuel	X	0
3	Eng 2 Chip	Eng 2 Start Fuel	X	0
4	Eng 1 Throttle-Ground	0	X	0
5	Eng 1 Throttle-Fly	0	X	0
6	Eng 2 Throttle-Ground	0	X	0
7	Eng 2 Throttle-Fly	0	X	0
8	Eng 1-Ignition	0	X	0
9	Eng 2-Ignition	0	X	0
10	Eng 1-Starter	0	X	0
11	Eng 2-Starter	0	X	0
12	0	0	X	Ground Contact
13	0	0	X	Faults Enable
14	0	0	X	Acknowledge
15	0	0	X	0

TABLE III

SUMMARY OF DIGITAL PROCESSOR CHARACTERISTICS

Type	- General purpose, stored program.
Number System	- Binary, fixed-point 2's complement, fractional.
Data Word Length	- 8, 16 bit standard, 32 bit double-precision.
Instruction Word Lengths	- 16 bits.
Register Structure	- Accumulator organized with 3 index registers.
Instructions	- Microprogrammed set of 117 including 9 application dependent opcodes.
Throughput	- 580 KOPS using a mix equation (40% Load/Store, 3% Multiply, 0.5% Divide, 5.5% Add, 5% Logical, 13% Branch, 32% Non-memory Reference).
Address Modes	- Direct, indirect, program counter and index register relative and immediate.
Interrupts	- 8 level, software maskable.
Memory Structure	- Two functional independent solid-state memories: Variable memory (scratchpad RAM) and program memory (RAM/PROM).
Variable Memory	- Minimum of 4K solid-state RAM for I/O data storage and scratchpad usage.
Program Memory	- Minimum of 12K solid-state RAM with battery for program and constant storage, shall be replaceable with solid-state ROM/PROM or external magnetic core memory.

TABLE III

SUMMARY OF DIGITAL PROCESSOR CHARACTERISTICS (Continued)

Input/Output	- Operate directly to/from the I/O RAM in either of three modes: Interrupt mode with software maskable linear priority, a non-interferrence DMA mode which does not disrupt CPU activity, or a processor controlled mode. Provisions for: o RS-232-C Channel for GSE interface o MIL-STD-1553B Data Link providing a standard, 1 MHz, Manchester II format, serial digital data link o Serial I/O to keyboard.
Resettable Iteration	- Software controlled external timing reference responds with interrupt.
Built-in-Fault Detection	- Computational overflow, divide, power supply monitor and watchdog monitor.

TABLE IV

SUMMARY OF RSG CHARACTERISTICS

Mode Parameters	
Frame/Field Rate	- 30/60 Hz
Interlace	- 2:1
Aspect Ratio	- 4:3
Scan Mode	- 525 Lines/Frame
Output Video Signal Format	- RS170 (Composite)
Synchronization	- External or Internal
Symbol Generation	
Image Buffer Configuration	- Two Memories
Update Technique	- Image Buffers used on Alternate Fields
Update Period	- 16.7 milliseconds (30/60 Hz Rate)
Update Rate	- 2 MHz
Resolution	- 640(H) x 480(V)
Symbol Attributes	
Symbol Positioning	- Under Digital Hardware Control
Position Resolution	
o Computational	- 16 bits
o Display Generator	- 12 bits
o Refresh Modes	- 10 bits
Symbol Types	- Line and Block filled with priority overlay
Double Entry	- Line/element weighting for improved symbol legibility

TABLE IV

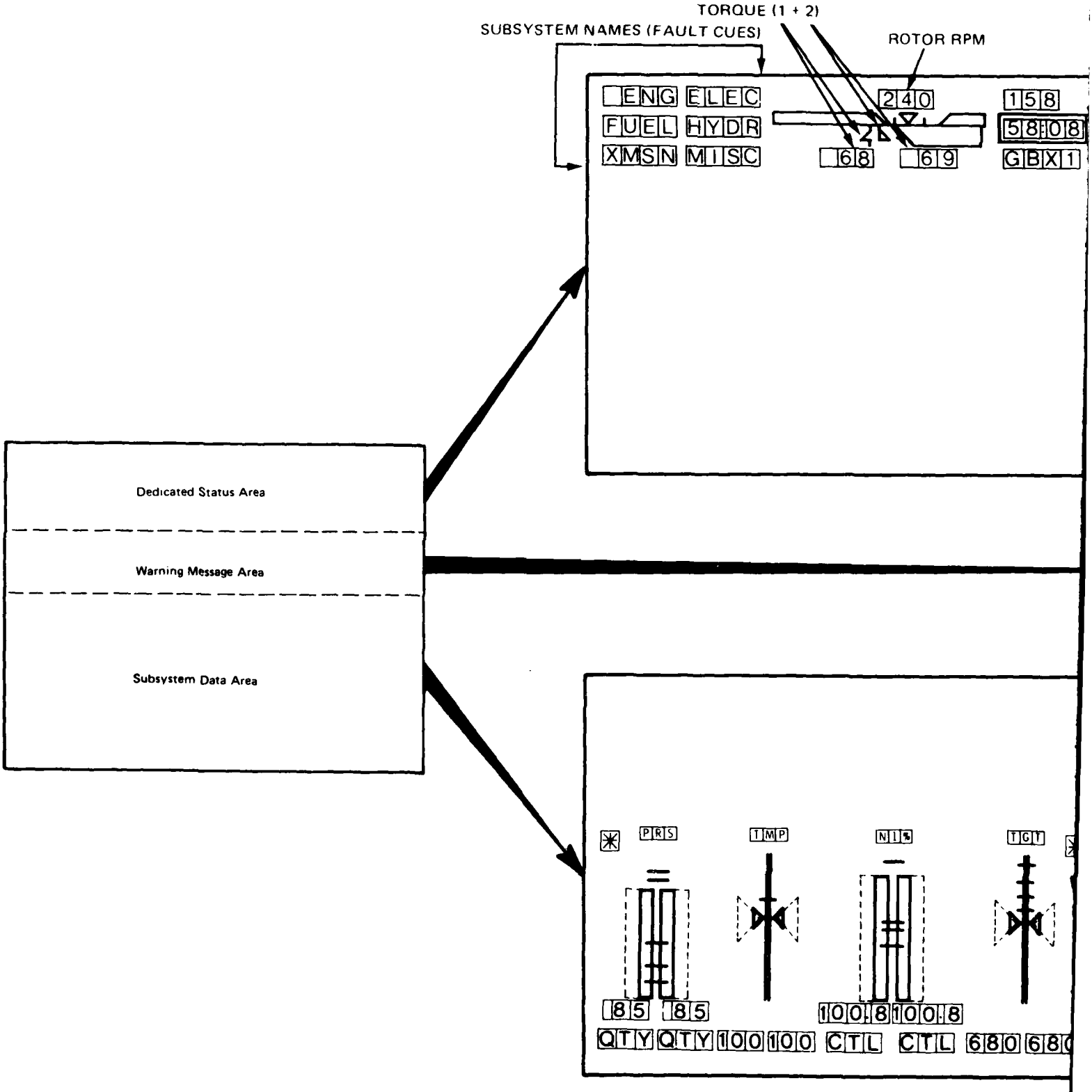
SUMMARY OF RSG CHARACTERISTICS (Continued)

Expansion Capability	
Color	- RGB Color plus Sync
Priority	- 8 priorities (Determined by color bits)

3.2.1.2 System. The EMMADS feasibility model software shall be designed to satisfy the functional performance characteristics defined by this specification. The EMMADS Operational Functions Report shall serve as a general guide whenever additional explanation is needed of how an actual EMMADS would perform in an aircraft. However, the requirements of this specification shall take priority over that report.

3.2.1.2.1 Formats. The EMMADS feasibility model shall be capable of displaying formats containing information divided into the three functional areas shown in Figure 2. (Note: In this and all other figures showing display formats, boxes are drawn around alphanumeric characters and may also be shown empty in other areas of display. These are not part of the format, but are used to indicate the amount of space reserved for these characters). The Dedicated Status Area is utilized for information requiring continuous display. The Warning Message Area is reserved for displaying up to six messages of eight characters each, under conditions described in 3.2.1.2.3.1. The Subsystem Data Area is utilized for displaying parameters in the engine, fuel, transmission, electrical, hydraulic and miscellaneous subsystems, as well as emergency action checklists. A summary of the associated parameters for the CH-47C is contained in Appendix I. Examples of the specific formats that the system shall be capable of displaying are shown in Figures 3.1 through 3.8. The EMMADS Acceptance Test Procedure shall be used as a guide in implementing specific functions exhibited by the formats.

3.2.1.2.1.1 Format 1. The example format shown in Figure 3.1 shall be capable of continuously displaying rotor rpm and torque for engines 1 and 2 (see Section 3.2.1.1.4, Table I) on the indicated scales. As these parameters are varied over their full dynamic range (Appendix I) the associated triangular shaped pointers shall move over the entire scale length and the corresponding stationary digital readout shall reflect the parameter


TORQUE (1 + 2)
SUBSYSTEM NAMES (FAULT CUES)
ROTOR RPM
ENG ELEC
FUEL HYDR
XMSN MISC
240
158
5808
68
69
GBX1
Dedicated Status Area
Warning Message Area
Subsystem Data Area
PRS
TMP
NI%
TGT
85 85
100.8 100.8
QTY QTY 100 100 CTL CTL 680 680

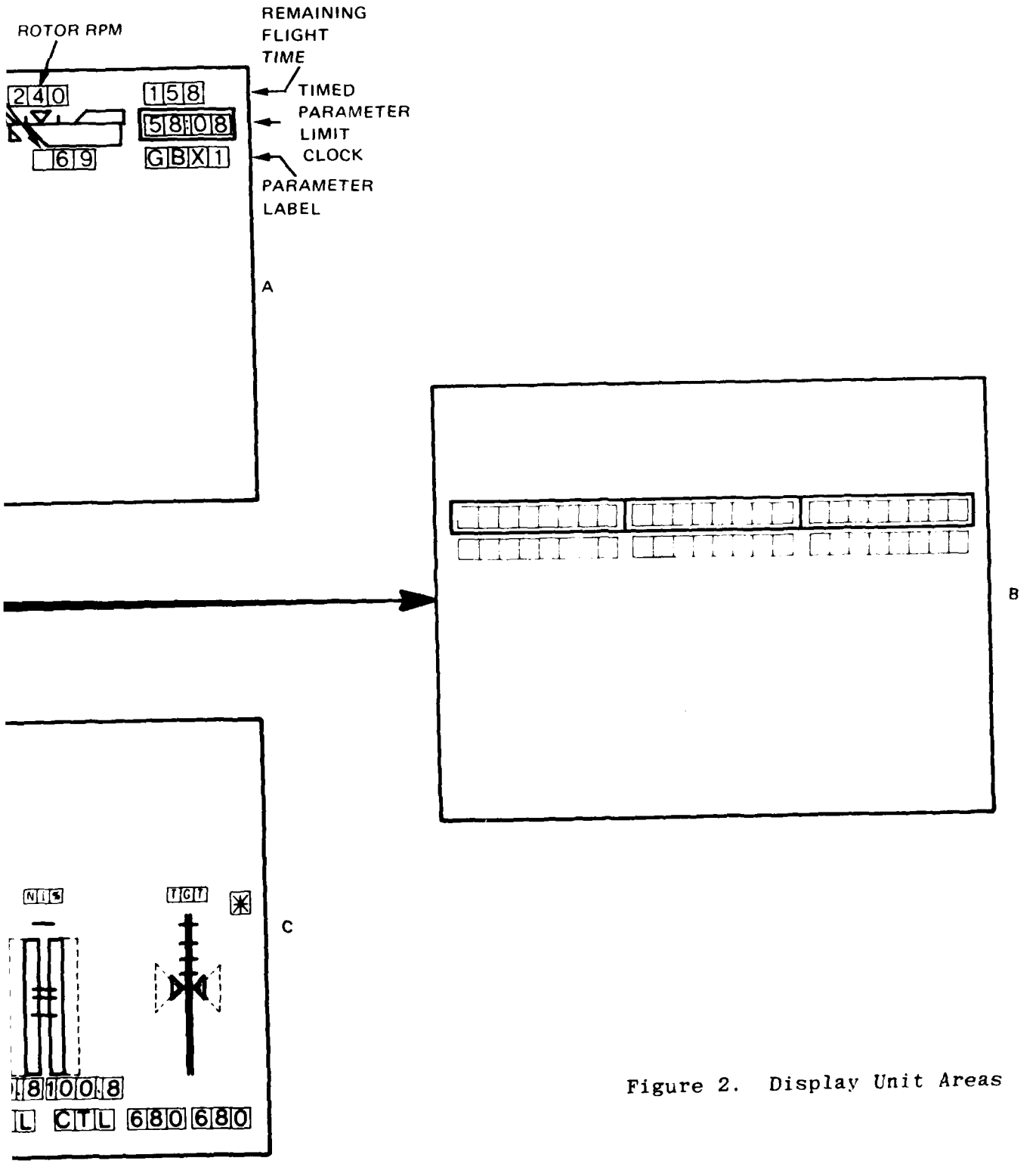


Figure 2. Display Unit Areas

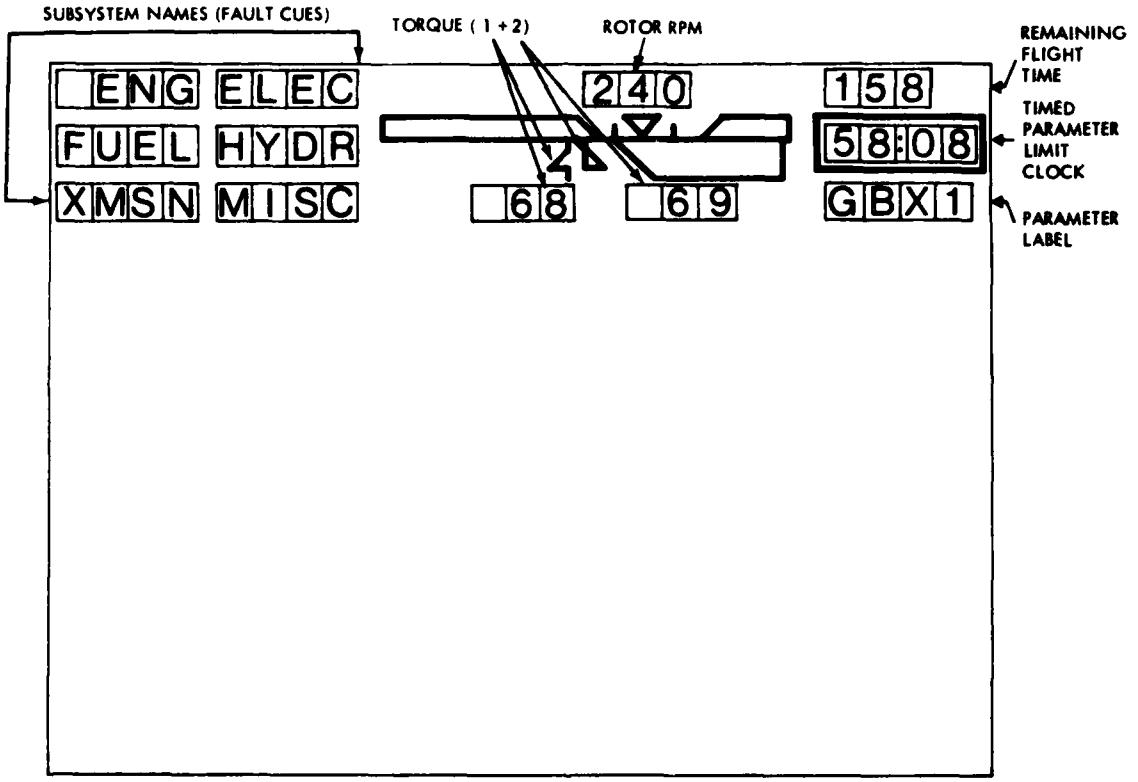


Figure 3.1. Display Format 1

value. Plateaus, such as those depicted on the scales, shall be used as range delimiters to indicate abnormal operating limits associated with the parameters. The positions of these plateaus shall be continuously computed so as to indicate the current operating limits, as they are defined by the data (parameters) received via the 1553B bus (see Appendix I and the EMMADS Acceptance Test Procedure). Static vertical tick marks shall be positioned on the rotor rpm scale at the 235 and 245 normal rotor rpm limits. Format 1 shall also continuously display a calculated value of flight time remaining (in minutes) in the position shown in Figure 3.1. The calculation shall be based on the equations below:

$$\begin{aligned}\text{Total Fuel} = {} & \text{Fuel Quantity Left Forward} + \\ & \text{Fuel Quantity Left Main} + \\ & \text{Fuel Quantity Left Aft} + \\ & \text{Fuel Quantity Right Forward} + \\ & \text{Fuel Quantity Right Main} + \\ & \text{Fuel Quantity Right Aft}\end{aligned} \qquad (1)$$

$$\text{Flight Time Remaining} = \text{Total Fuel}/37 \ (\text{lbs/min}) \qquad (2)$$

The system shall also have the capability of displaying the remaining format information shown in Figure 3.1. This informa tion shall be selected for inclusion in the format under the conditions defined in 3.2.1.2.3.2. Finally, the system shall provide the capability for flashing the rotor rpm and torque scale pointers, the subsystem names and the parameter labels, under the conditions defined in 3.2.1.2.3.2.

3.2.1.2.1.2 Format 2. An example of this format is shown in Figure 3.2. It includes information in all three of the display areas specified in 3.2.1.2.1. That is, this format (as well as Formats 3 through 8) includes Format 1 as a constituent part of the displayed information. The conditions under which information

will appear in the Warning Message Area of Formats 2 through 8 are specified in 3.2.1.2.3.2. As shown in Figure 3.2 this engine subsystem format shall display engine oil pressure (PRS), engine oil temperature (TMP), engine gas producer speed (N1%) and engine turbine gas temperature (TGT) data on analog scales. Scale indicator symbology shall alternate between tape ("thermometer" type) and pointer (triangles) scales, as shown. For each scale pair, the left scale shall correspond to the No. 1 engine and the right scale to the No. 2 engine. Each indicator symbol (tapes and triangles) shall be capable of doubling in size, as exemplified in the figure by the dotted lines around each such symbol. Any such oversized symbol shall also have the capability to flash and/or be filled in (appear solid). The system shall have the capability of placing horizontal tick marks on each scale. The ticks shall be controlled separately for each engine scale and not on a scale pair basis (e.g. the tick marks for the No. 1 and No. 2 engine oil pressure scales are to be separately controlled). Each engine oil pressure scale shall display two tick marks to indicate the current normal operating range for each parameter, as defined in Appendix I. Each engine gas producer (N_1) scale shall have a tick mark positioned at the applicable minimum operating speed. In addition, the N_1 scales shall have a tick mark positioned at 45% when the engine starter, start fuel and ignition dicretes for a given engine(s) are all sensed active (high). Each turbine gas temperature scale shall display two ticks to indicate the normal operating temperature range for an engine operating below that maximum normal temperature. For an engine operating above that maximum, two tick marks shall be displayed to indicate the extent of the time-limited, cautionary operating range within which the TGT currently lies (see Appendix I). Finally, all scales shall continuously display a tick mark at the absolute maximum "never to exceed" limit. All such limits indicated by tick marks shall be those detailed in Apendix I. All scales shall have the actual numeric value of the analog parameter displayed directly under the scale bottom, as shown in

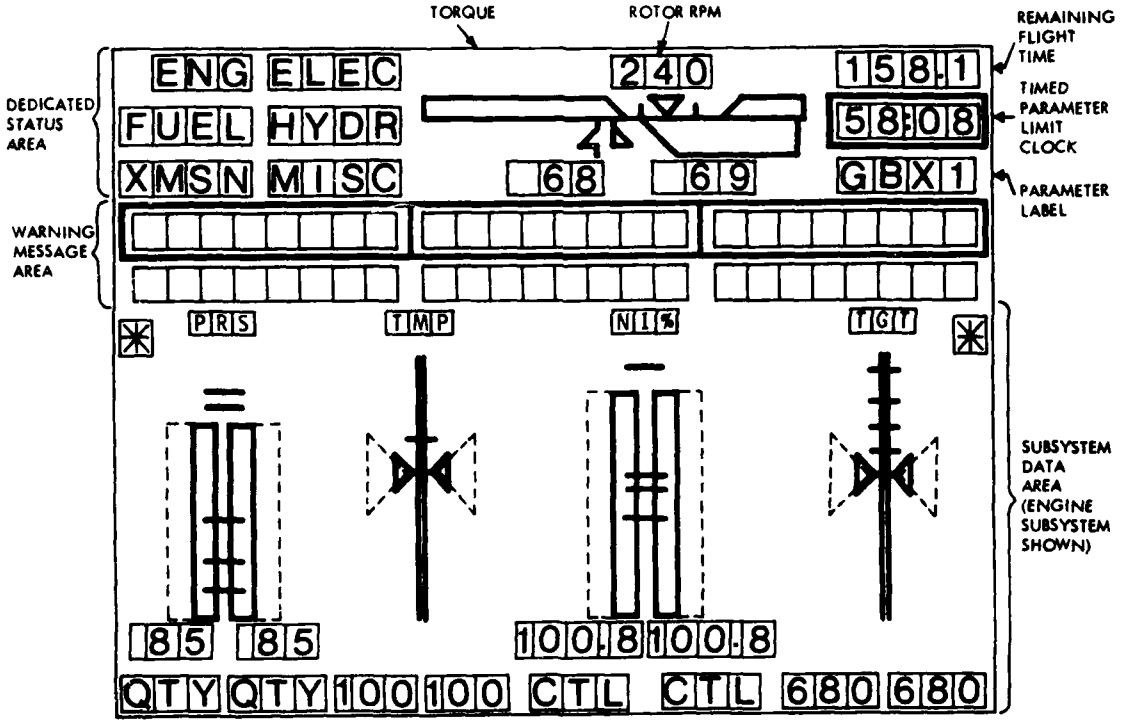


Figure 3.2. Display Format 2

the figure. Engine subsystem discrete sensor states are also displayed on this format, using the left and right side asterisks (*) and the words QTY and CTL. The system shall also be able to flash these symbols/words. The left and right asterisks shall be activated by the engine 1 and 2 chip data discretes respectively. The left and right QTY words shall be activated by the engine 1 and 2 low oil quantity discrete data bits respectively. The left CTL word shall be activated by the engine 1 throttle fly and ground data discretes combination and the right CTL word shall be activated by the engine 2 throttle fly and ground data discretes combination. Activation is accomplished when the related discretes are high (logic state "1"), as specified in Appendix II.

3.2.1.2.1.3 Format 3. An example of this format is shown in Figure 3.3. The format is used to represent the status of fuel subsystem parameters (along with Format 1 parameters). The system shall be capable of displaying in this format, the numeric values of the simulated fuel tank quantities received via the 1553B bus. These numbers shall be displayed as follows:

Data Word (Table I)	Box (Tank) in Format 3
Fuel Quantity - Left, Forward	Top left
Fuel Quantity - Left, Main	Center left (large tank)
Fuel Quantity - Left, Aft	Bottom left
Fuel Quantity - Right, Forward	Top right
Fuel Quantity - Right, Main	Center right (large tank)
Fuel Quantity - Right, Aft	Bottom right

Total fuel (Section 3.2.1.2.1.1, equation (1)) value shall be displayed under the word TOTAL as shown in Figure 3.3. In addition, the open triangle next to the top left box shall flash.

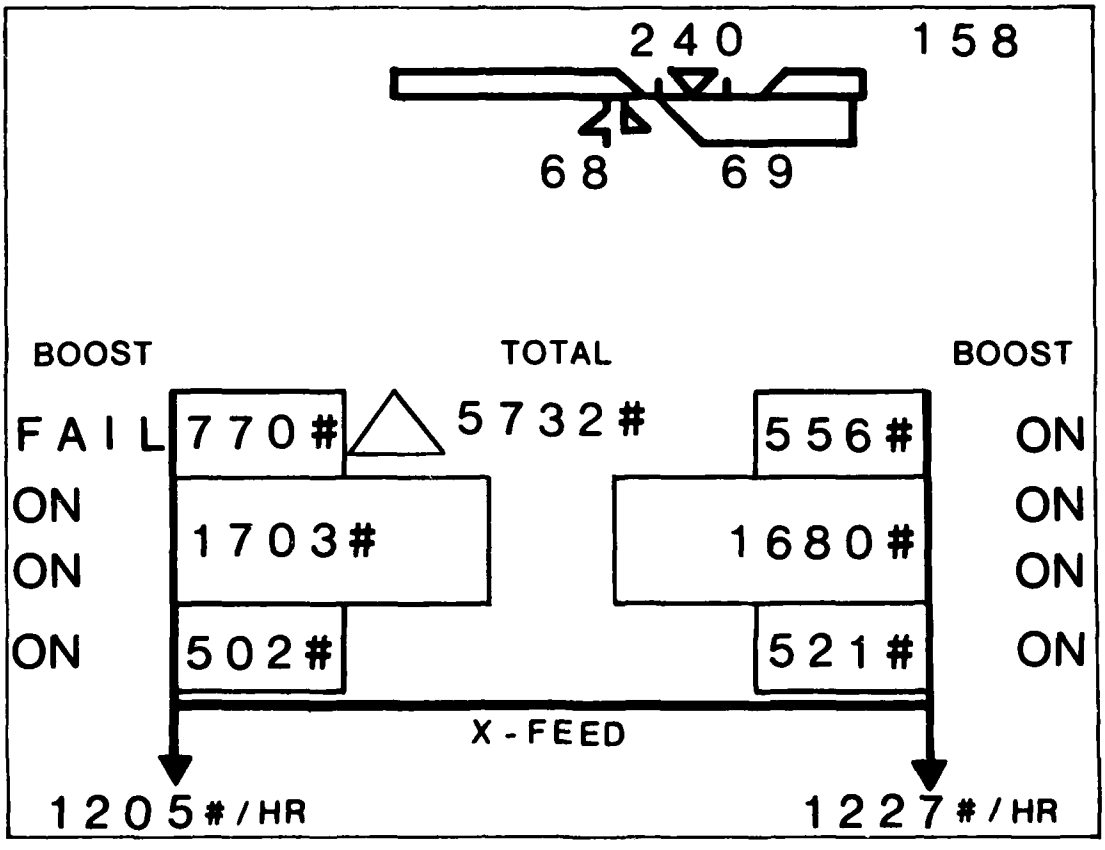


Figure 3.3. Display Format 3

3.2.1.2.1.4 Format 4. An example of this format is shown in Figure 3.4. The format is used to represent the status of transmission (XMSN) subsystem parameters (along with Format 1 parameters). The system shall be capable of displaying, in this format, the numeric values of the simulated transmission oil pressures and temperatures received via the 1553 bus. The pressure and temperature for each transmission shall be displayed, (left to right respectively), in the appropriate box on the format, as described below:

Data Word (Table I)	Box (XMSN) on Format 4
Forward XMSN Oil Press and Temp	Top
Eng 1 XMSN Oil Press and Temp	Left
Combining XMSN Oil Press and Temp	Center
Eng 2 XMSN Oil Pres and Temp	Right
Aft XMSN Oil Press and Temp	Bottom

3.2.1.2.1.5 Format 5. An example of this format is shown in Figure 3.5. The format is used to represent the status of electrical subsystem parameters (along with Format 1 parameters). The numeric value of the Generator 2 Load, Rectifier 1 Load and Rectifier 2 Load data words (see Table I) shall be displayed in this format in the appropriate positions.

3.2.1.2.1.6 Format 6. An example of this format is shown in Figure 3.6. The format is used to represent the status of hydraulic subsystem parameters (along with Format 1 parameters). The numeric value of the #1 Hydraulic Pressure (FLT CTRL PRS-SYS1), #2 Hydraulic Pressure (FLT CTRL PRS-SYS2), Utility Hydraulic Pressure (UTILITY PRS) and APU Accumulator Pressure (APU ACCUM PRS) data words (see Table I) shall be displayed in this format in the appropriate positions.

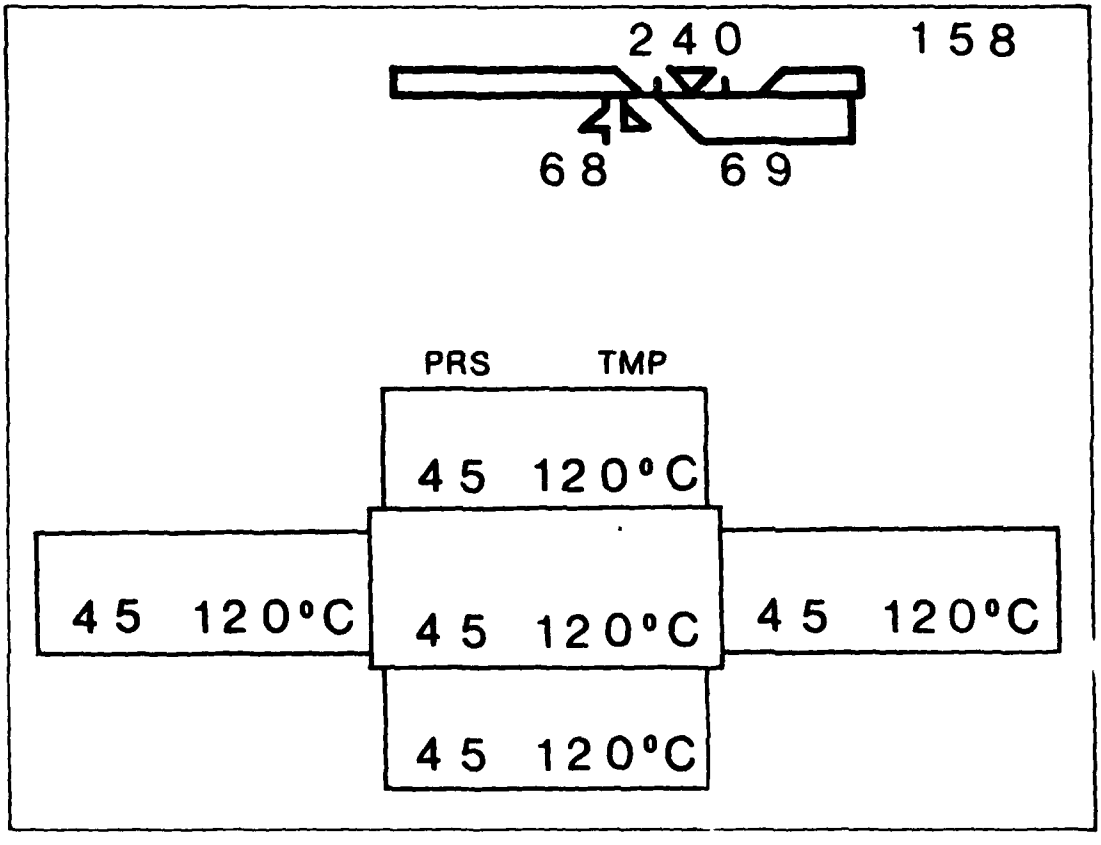


Figure 3.4. Display Format 4

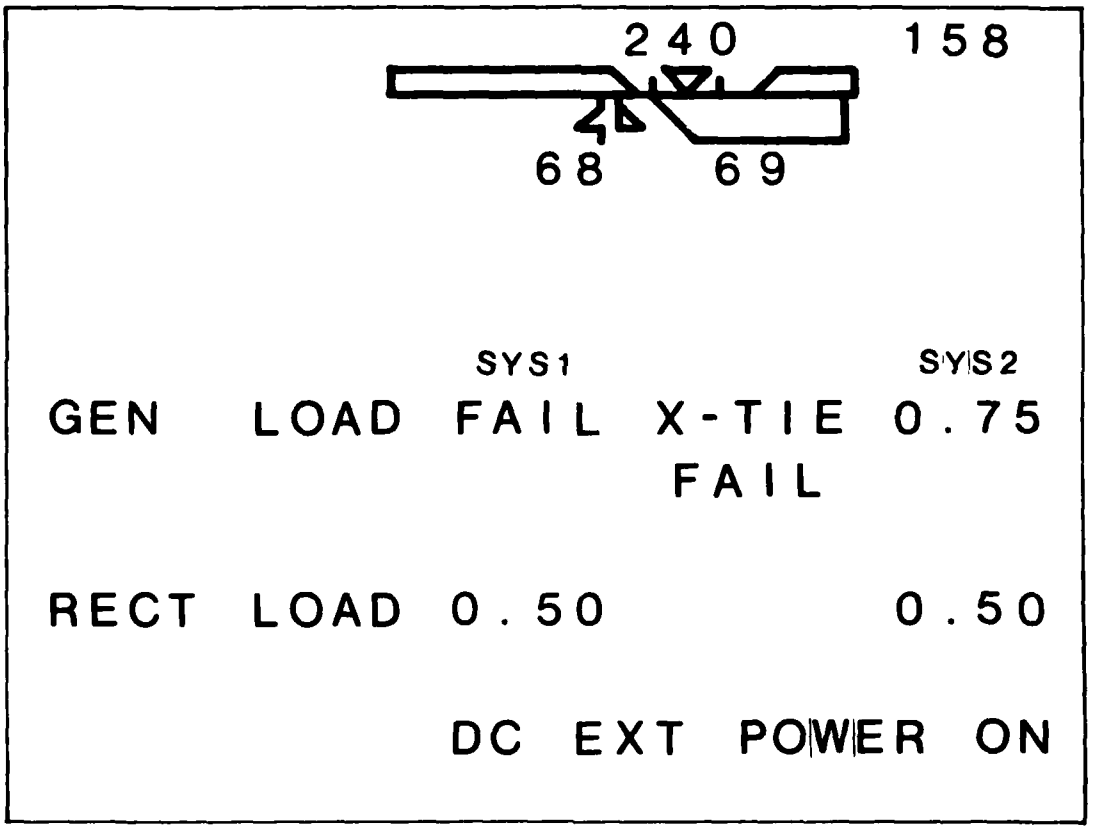


Figure 3.5. Display Format 5

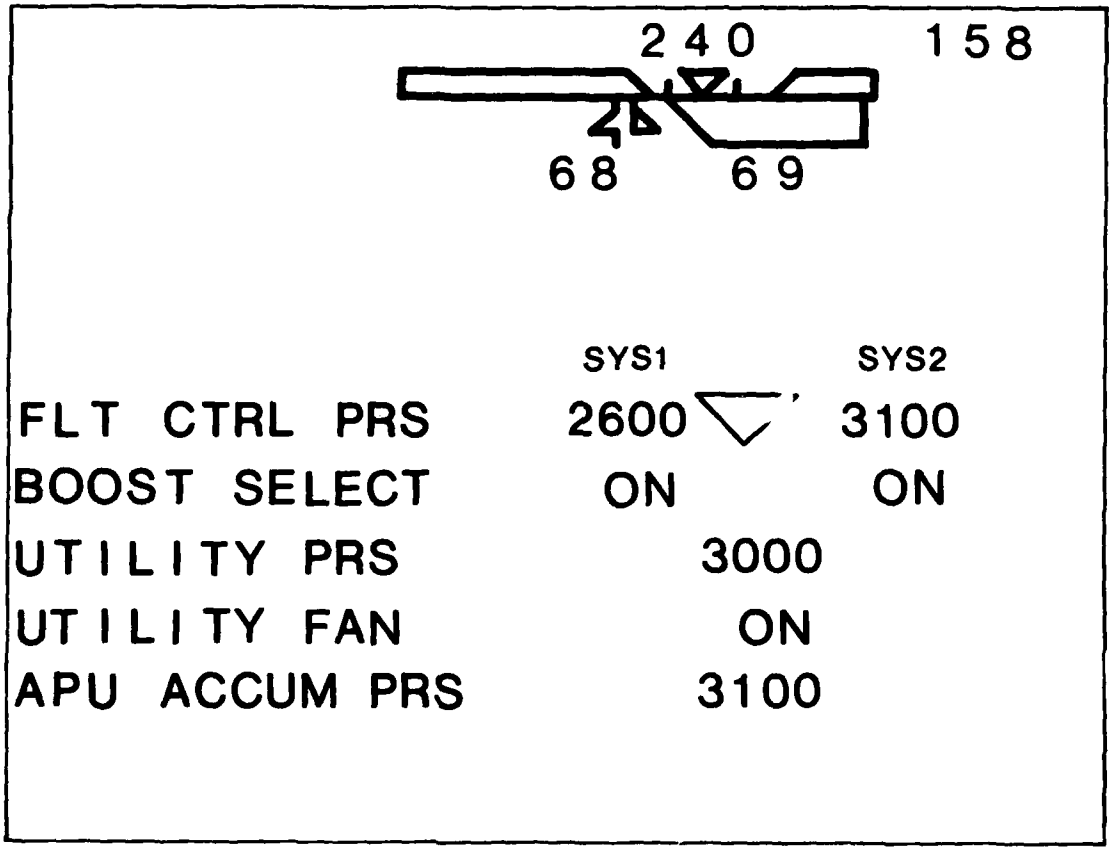


Figure 3.6. Display Format 6

3.2.1.2.1.7 Format 7. An example of this format is shown in Figure 3.7. The format is used to represent the status of parameters in the miscellaneous subsystem (along with Format 1 parameters). The system shall make provision for display of (TBD) data received via the 1553B bus.

3.2.1.2.1.8 Format 8. An example of this format is shown in Figure 3.8. The format is used to display emergency action checklists applicable to the engine subsystem (in the indicated display area), in conjunction with Format 1 parameters and some Format 2 parameters. (This includes all parameters normally displayed in the right half of Format 2.) The checklist area shall be capable of displaying checklists consisting of seven lines of 12 character spaces each. The system shall be capable of displaying any of the checklists shown in Table V in the indicated area of this format.

The display of each checklist applicable to this format shall be as specified in 3.2.1.2.2 and 3.2.1.2.3.3.

3.2.1.2.2 Manually Commanded Operations. The system shall provide the capability to select the formats described in Section 3.2.1.2.1 for display during periods when no "new" faults are detected. System design will be such as will allow for the addition of maintenance test flight checklists, performance calculations, maintenance data summary and system Built-In-Test formats to the manual selection capability of future system versions.

Manual selection of display information is provided by the Multilegend Display Switches (MLDS). The operation of the MLDS shall be structured to provide three basic levels of format selection capability: subsystem information, routine checklists, and performance calculations. Access to these levels is controlled by one of the MLDs (the right-most switch) as shown in

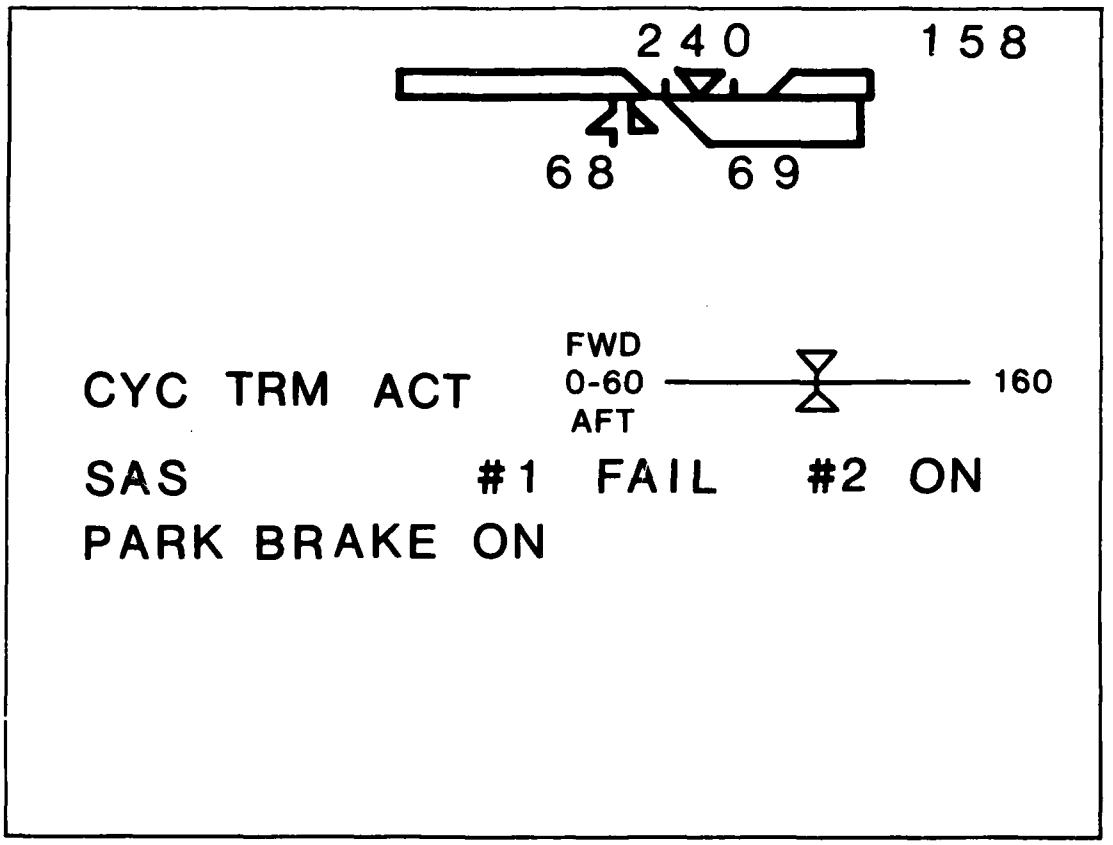


Figure 3.7. Display Format 7

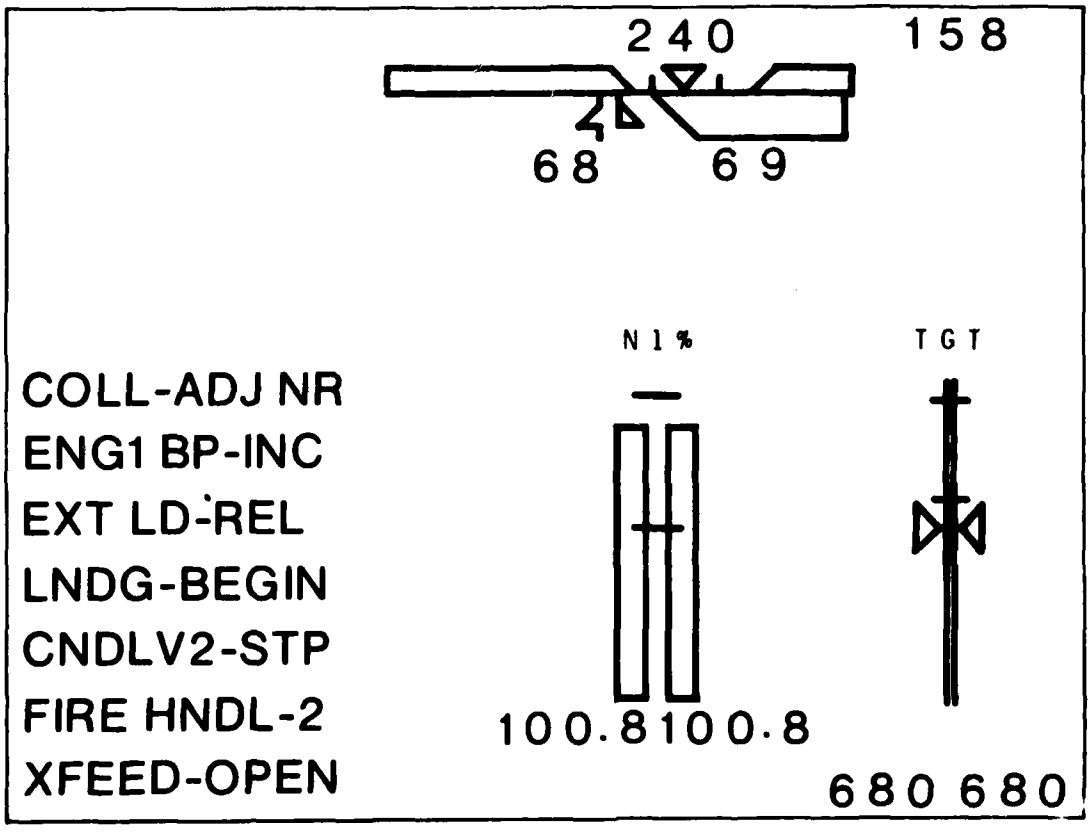


Figure 3.8. Display Format 8

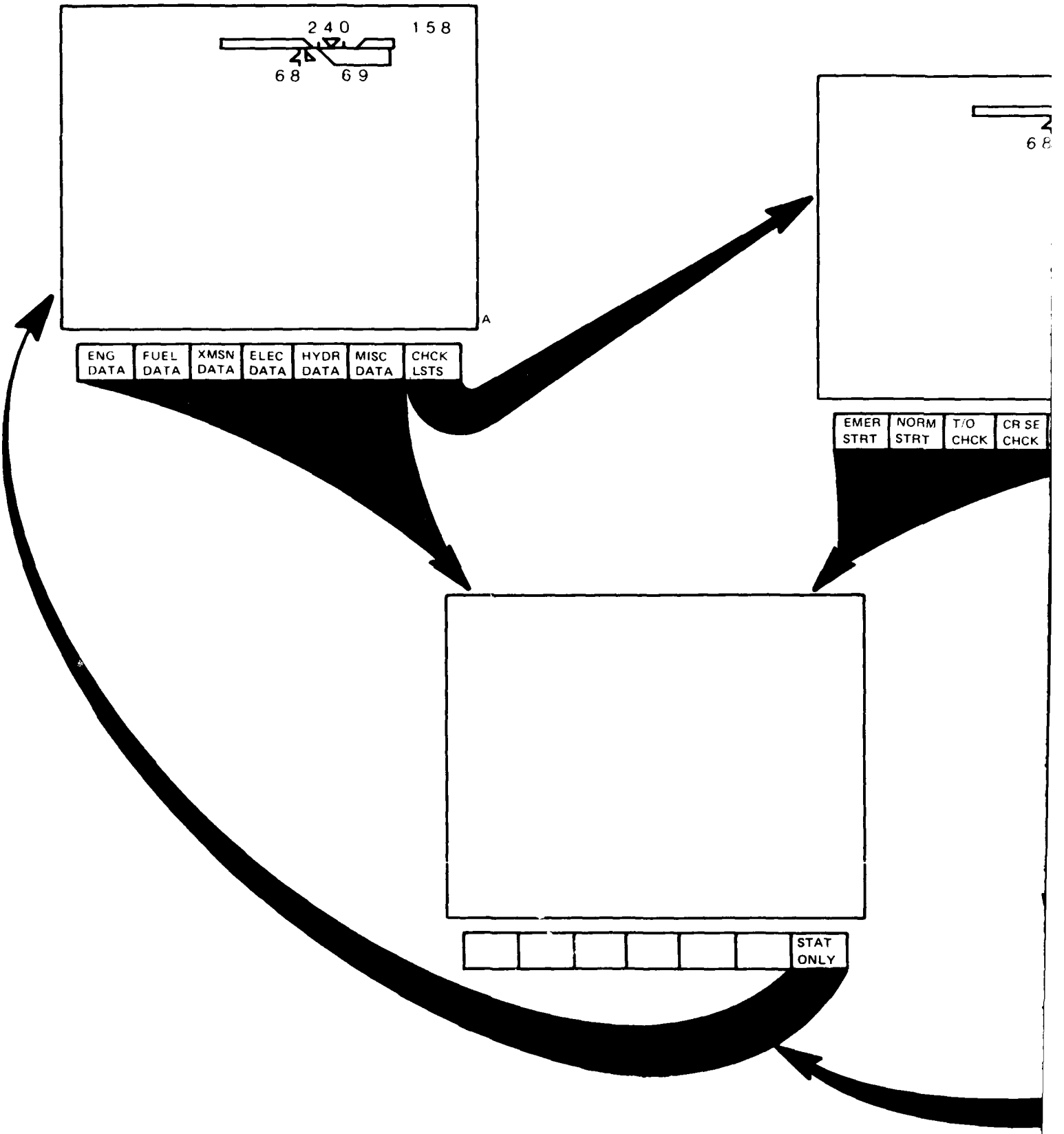
TABLE V

ENGINE SUBSYSTEM EMERGENCY ACTION CHECKLISTS

No.	Text
1	COLL-ADJ NR
2	COLL-ADJ NR EXT LD-REL LNDG-BEGIN CND LV1-STP CND LV2-STP FIRE HNDL-1 FIRE HNDL-2
3	COLL-ADJ NR ENG2 BP-INC EXT LD-REL LNDG-BEGIN CND LV1-STP FIRE HNDL-1 XFEED-OPEN
4	COLL-ADJ NR ENG1 BP-INC EXT LD-REL LNDG-BEGIN CND LV2-STP FIRE HNDL-2 XFEED-OPEN

Figure 4 (a through d). The normal condition of the DU and MLDS is depicted in Figure 4a which is the subsystem information level. Note that the first six MLDS legends relate to the aircraft subsystems. Depressing the seventh switch (labeled "CHCK LSTS") alters all MLDS legends (labels) as shown in Figure 4b and the format selection level is now that of routine checklists. The first six MLDS labels now indicate which such checklists could be selected. Depressing the seventh switch (now labeled "PERF CALC") again relegends the MLDS as shown in Figure 4c and the format selection level is now that of performance calculations, where the switch legends indicate aircraft performance calculations formats which could be accessed. (Note also that an EMMADS system self test selection capability has been provided for later system expansion.) At this point, depressing any of the first six MLDS will have no effect. Depressing the "STAT ONLY" switch now causes a return to the subsystem information level. In Figure 4d, note that the information on the DU is no longer simply that of the Dedicated Status Area, but depends on what the pilot has selected by depressing one of the MLDS. In the case where a "DATA" switch is depressed (Figure 4a), this results in the display of the appropriate engine subsystem data (Formats 2 through 7). In the case where a routine checklist switch is depressed (Figure 4b), there shall be no change in the display (Format 1 remains). The system shall allow for expansion of capabilities to select checklist formats at some future time. Whenever one of these first six MLDS is depressed, the right-most switch legend is changed to read "STAT ONLY", as shown. Depressing this switch then selects Format 1 for display while simultaneously returning the MLDS labels to the subsystem information format selection level.

Manual selection capability is expanded on the subsystem information format selection level whenever a specific format is selected. For example, as shown in Figure 5a, when engine subsystem data is selected for display, the Subsystem Data Area


240
158
68
69
A
ENG DATA
FUEL DATA
XMSN DATA
ELEC DATA
HYDR DATA
MISC DATA
CHCK LSTS
68
EMER STRT
NORM STRT
T/O CHCK
CR SE CHCK
STAT ONLY

A. Subsystem Information Level

(Note that only Dedicated Status Area information is on the Display Unit)

B. Routine Checklist Level

(Note that only Dedicated Status Area information is on the Display Unit)

C. Performance Calculation Level

(Note that only Dedicated Status Area information is on the Display Unit)

D. The "STAT ONLY" legend appears on the last switch whenever any of the indicated switches are o.. ressed. The information on the Display Unit and the other switch legends are discussed in the text.

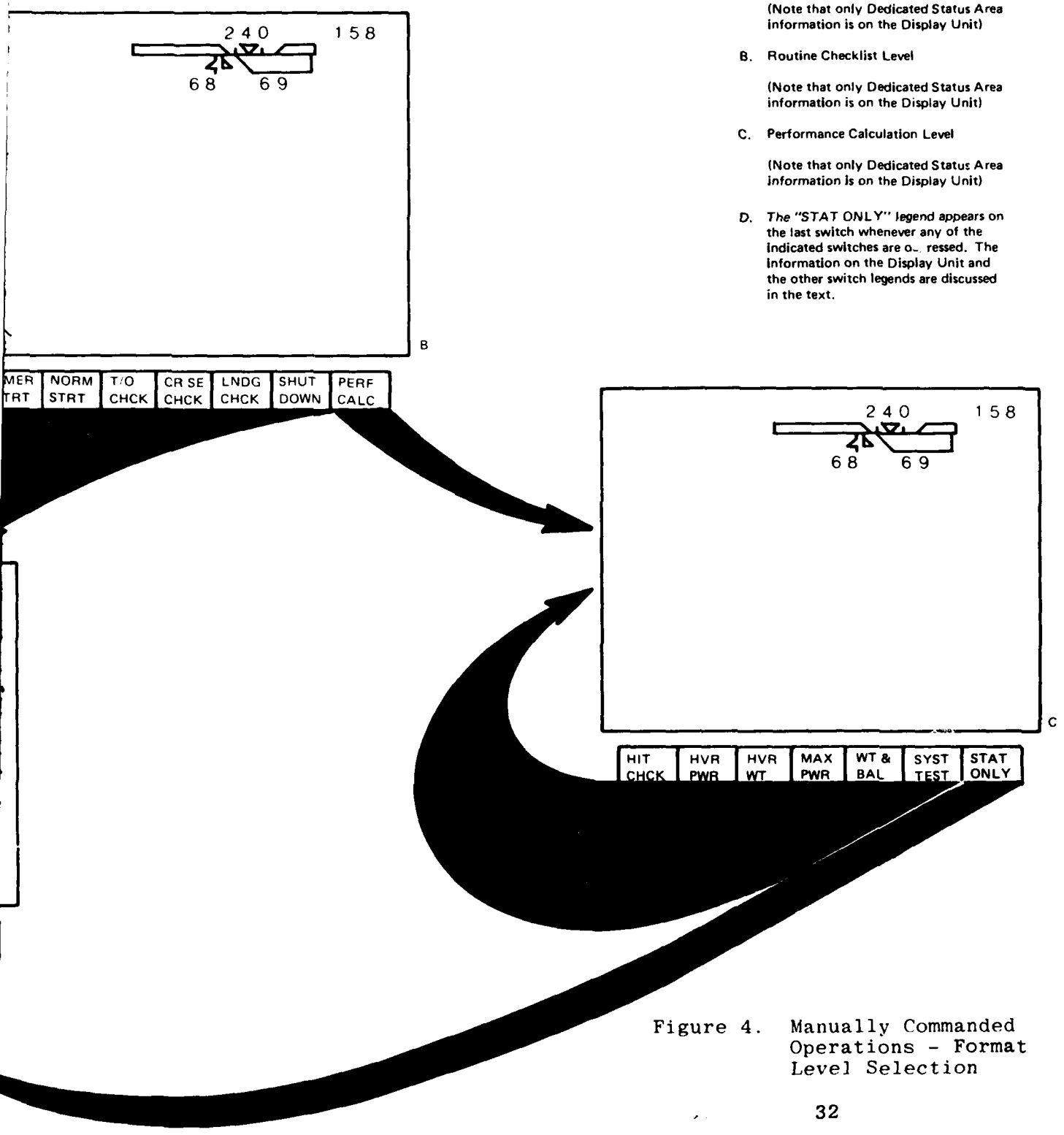
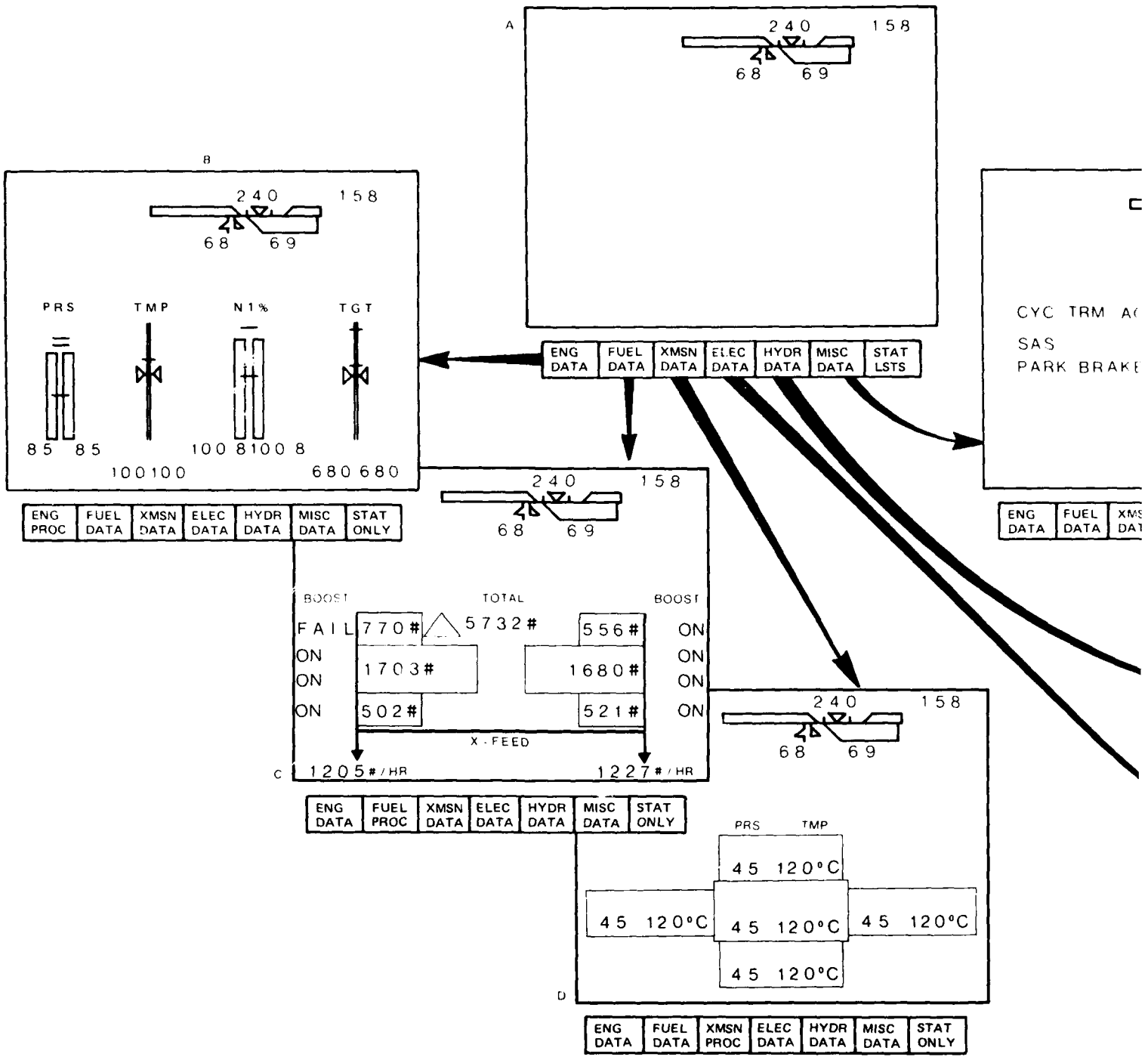


Figure 4. Manually Commanded Operations - Format Level Selection


A
240
158
68
69
ENG DATA
FUEL DATA
XMSN DATA
ELEC DATA
HYDR DATA
MISC DATA
STAT LSTS
B
240
158
68
69
PRS
TMP
N1%
TGT
85 85
100 8100 8
100100
680 680
ENG PROC
FUEL DATA
XMSN DATA
ELEC DATA
HYDR DATA
MISC DATA
STAT ONLY
CYC TRM A
SAS
PARK BRAK
ENG DATA
FUEL DATA
240
158
68
69
BOOST
TOTAL
BOOST
FAIL
770#
5732#
556#
ON
ON
1703#
1680#
ON
ON
ON
502#
521#
ON
X-FEED
C
1205#/HR
1227#/HR
ENG DATA
FUEL PROC
XMSN DATA
ELEC DATA
HYDR DATA
MISC DATA
STAT ONLY
240
158
68
69
PRS
TMP
45 120°C
45 120°C
45 120°C
45 120°C
D
ENG DATA
FUEL DATA
XMSN PROC
ELEC DATA
HYDR DATA
MISC DATA
STAT ONLY

A. Display Unit and MLDS in normal operations mode (No Faults - Subsystem Information Level Selected)

B. Engine Subsystem Data Selected

C. Fuel Subsystem Data Selected

D. Transmission Subsystem Data Selected

E. Electrical Subsystem Data Selected

F. Hydraulic Subsystem Data Selected

G. Miscellaneous Subsystem Data Selected

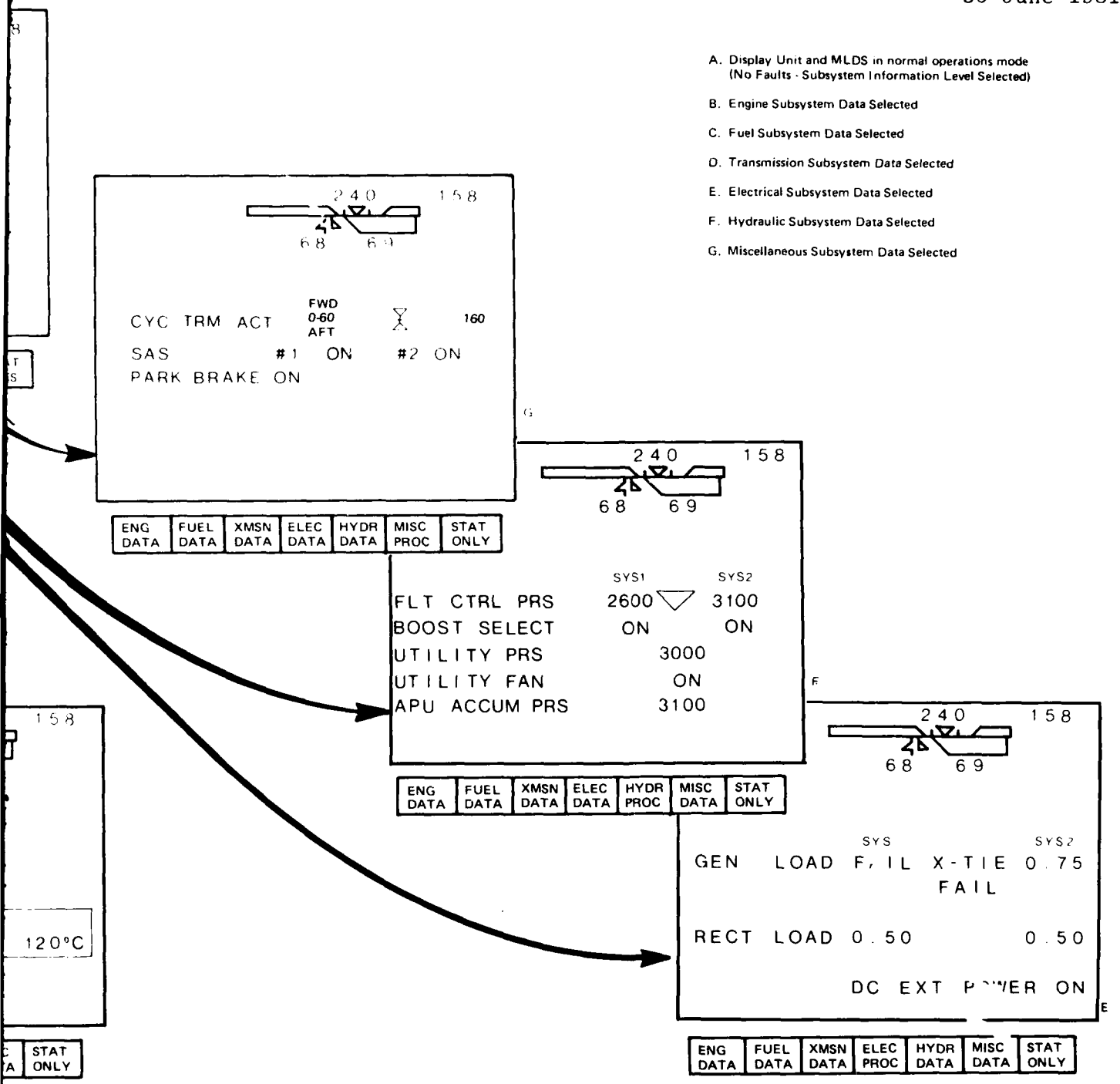
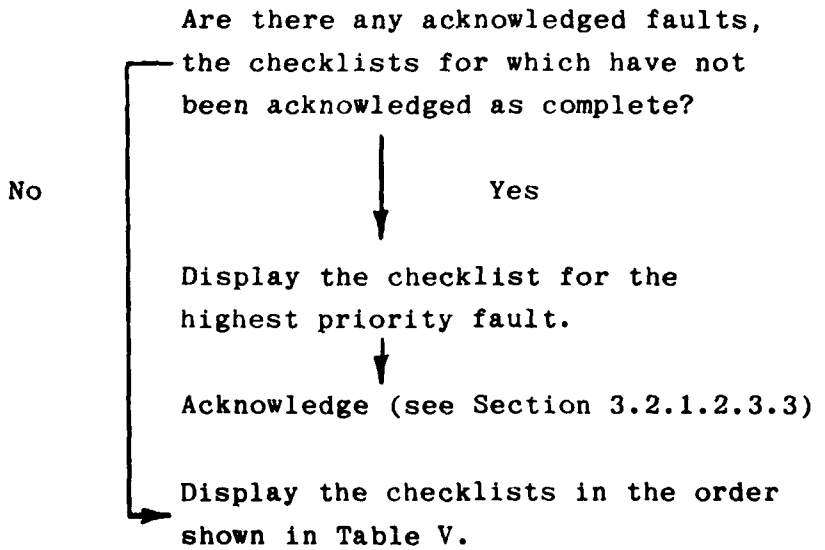


Figure 5. Manually Commanded Operations - Subsystem Information Level

on the DU is utilized to display the current status of all analog and discrete parameters of the subystem (Format 2) and the switch legend changes from "ENG DATA" to "ENG PROC". (Of course, the right-most switch legend also changes to "STAT ONLY" as previously described, because the DU no longer displays only Dedicated Status Area Information). Similar operations are possible for the fuel, transmission (XMSN), electrical, hydraulic and miscellaneous subsystems (Formats 3 through 7), as shown in Figures 5c through 5g. Note the change in the MLDS labels which shall result when the indicated subsystem "data" switch is depressed. In the case of any MLDS with a "PROC" legend, except for the "ENG PROC" MLDS legend, actuation of that MLDS shall have the same effect as depressing the "STAT ONLY" switch. In the case of the "ENG PROC" MLDS, depressing that switch shall cause Format 8 to be displayed. The "ENG PROC" switch label does not change when the format is selected. This is because each time that switch is depressed while bearing that label, a different emergency action checklist is selected for display (see Table V).

The order in which these checklists appear shall be based on the decision logic below:



For the path where no unacknowledged checklists are pending, each checklist in Table V is displayed in Format 8 by successive actuations of the "ENG PROC" MILDS. When the fourth (last) checklist is displayed, the next actuation of that MLDS shall have the same effect as the "STAT ONLY" MLDS. Acknowledgement of checklists associated with active faults shall be as specified in 3.2.1.2.3.3.

3.2.1.2.3 Fault Commanded Operations. The system shall be capable of monitoring data on the 1553B bus for fault conditions and displaying any faults on the DU. It shall be able to respond to a fault acknowledgement command received via either the 1553B bus or the MLDS. It shall display certain emergency action checklists (Table V) in response to either fault acknowledgement or MLDS inputs. It shall also be able to update MLDS legends and functions in conjunction with the above functions. Fault commanded operations shall take priority over any operations.

3.2.1.2.3.1 Fault Detection. The system shall continuously monitor 1553B bus data for fault conditions possible on a CH-47C helicopter. There are two basic fault types which the system shall demonstrate its ability to detect: Single parameter faults and multiple parameter faults. Searching for single parameter faults requires examining individual parameters for an out of tolerance condition. A multiple parameter fault can be discovered by correlating the values of various related parameters (e.g. gas producer speed, turbine gas temperature and torque may be correlated to determine the possibility of engine failure).

In order to provide notification of faults on an "as needed" basis, the system shall utilize a fault priority structure, which breaks faults down into three categories:

a. Warnings - those faults which, if not immediately acted upon by the crew, will most probably result in seriously compromising the pilot's ability to control the aircraft, thereby resulting in personal injury or loss of life.

b. Cautions/Precautions - those faults which do not immediately jeopardize the pilot's ability to control the aircraft, but which may result in equipment damage and/or the compromise of crew safety if not attended to (A fault condition in this category, if allowed to continue without corrective action being taken, may precipitate one or more Warnings).

c. Advisories - these are conditions (actually parameter states) which the pilot should be aware of, but which have a minimum chance of causing equipment damage or injury. (e.g. DC External Power On).

Table VI details the fault priority scheme for a CH-47C. The EMMADS feasibility model will utilize this table to determine the manner and order of fault presentation on the DU. In particular, the system shall be able to detect all Cautions/Precautions in the engine subsystem and the following warnings:

Rotor RPM Limit
No. 1 and No. 2 Engines Failed
No. 1 Engine Failed
No. 2 Engine Failed

TABLE VI. FAULT PRIORITIZATION FOR THE CH-47C HELICOPTER

Fault	Subsystem Displayed	Priority
WARNINGS		
Quill Shaft Failure	Hydraulic	1
Rotor RPM Limit (continuous display)	Engine	2
No. 1 Engine Beep Trim High Side Failure	Engine	3
No 2. Engine Beep Trim High Side Failure	Engine	3
No. 1 Engine N_2 Sensing Failure	Engine	3
No. 2 Engine N_2 Sensing Failure	Engine	3
No. 1 Engine Beep Trim Low Side Failure	Engine	4
No. 2 Engine Beep Trim Low Side Failure	Engine	4
No. 1 & 2 Engines Failed	Engine	4
No. 1 Engine Failed	Engine	5
No. 2 Engine Failed	Engine	5
No. 1 Flight Control Hydraulic Press Low	Hydraulic	6
No. 2 Flight Control Hydraulic Press Low	Hydraulic	6
Eng. 1 & 2 Fuel Boost Press Limit (PA >6000')	Fuel	7
Eng. 1 Fuel Boost Press Limit (PA >6000')	Fuel	8
Eng. 2 Fuel Boost Press Limit (PA >6000')	Fuel	8
No. 1 and 2 SAS OFF	Miscellaneous	9
CAUTIONS/PRECAUTIONS		
Eng. 1 PTIT Limit	Engine	10
Eng. 2 PTIT Limit	Engine	10
Eng. 1 Torque Limit (continuous display)	Engine	10
Eng. 2 Torque Limit (continuous display)	Engine	10
Eng. 1 N_1 Limit	Engine	10
Eng. 2 N_1 Limit	Engine	10
Eng. 1 Oil Press Limit	Engine	10
Eng. 2 Oil Press Limit	Engine	10
Eng. 1 Oil Temp Limit	Engine	10
Eng. 2 Oil Temp Limit	Engine	10
Eng. 1 Chip Detected	Engine	10
Eng. 2 Chip Detected	Engine	10

TABLE VI
FLIGHT PRIORITIZATION FOR THE CH-47C HELICOPTER (cont'd)

Fault	Subsystem Displayed	Priority
CAUTIONS/PRECAUTION (cont'd)		
Eng. 1 Oil Level Limit	Engine	10
Eng. 2 Oil Level Limit	Engine	10
Eng. 1 N_1 Control Loop Energized	Engine	10
Eng. 2 N_1 Control Loop Energized	Engine	10
Fuel Qty-Left, Fwd Limit	Fuel	11
Fuel Qty-Left, Main Limit	Fuel	11
Fuel Qty-Left, Aft Limit	Fuel	11
Fuel Qty-Right, Fwd Limit	Fuel	11
Fuel Qty-Right, Main Limit	Fuel	11
Fuel Qty-Right, Aft Limit	Fuel	11
Eng. 1 Fuel Boost Press Limit (PA $\leq$6000')	Fuel	11
Eng. 2 Fuel Boost Press Limit (PA $\leq$6000')	Fuel	11
Fuel Boost Press, Left, Fwd Limit	Fuel	11
Fuel Boost Press, Left, Aft Limit	Fuel	11
Fuel Boost Press, Right, Fwd Limit	Fuel	11
Fuel Boost Press, Right, Aft Limit	Fuel	11
Eng. 1 Fuel Flow High	Fuel	11
Eng. 2 Fuel Flow High	Fuel	11
Eng. 1 Xmsn Oil Press Limit	Powertrain	12
Eng. 2 Xmsn Oil Press Limit	Powertrain	12
Combining Xmsn Oil Press Limit	Powertrain	12
Fwd Xmsn Oil Press Limit	Powertrain	12
Aft Xmsn Oil Press Limit	Powertrain	12
Eng. 1 Xmsn Oil Temp Limit	Powertrain	12
Eng. 2 Xmsn Oil Temp Limit	Powertrain	12
Combining Xmsn Oil Temp Limit	Powertrain	12
Fwd Xmsn Oil Temp Limit	Powertrain	12
Aft Xmsn Oil Temp Limit	Powertrain	12
Combining Xmsn Chip Detected	Powertrain	12
Fwd Xmsn Chip Detected	Powertrain	12
Aft Xmsn Chip Detected	Powertrain	12
Aft Thrust Bearing Chip Detected	Powertrain	12
No. 1 Generator Load Limit	Electrical	13
No. 2 Generator Load Limit	Electrical	13
No. 1 & 2 Generators Failed	Electrical	13
No. 1 Rectifier Load Limit	Electrical	13
No. 2 Rectifier Load Limit	Electrical	13
No. 1 & 2 Rectifiers Failed	Electrical	13
AC Bus X-Tie Failure	Electrical	13
DC Bus X-Tie Failure	Electrical	13

TABLE VI
FAULT PRIORITIZATION FOR THE CH-47C HELICOPTER (Cont'd)

Fault	Subsystem Displayed	Priority
CAUTIONS/PRECAUTIONS (Cont'd)		
No. 1 Flight Control Hydraulic Press High	Hydraulic	14
No. 2 Flight Control Hydraulic Press High	Hydraulic	14
Utility Hydraulic Press Limit	Hydraulic	14
Utility Hydraulic Temp Limit	Hydraulic	14
APU Accumulator Press Limit	Hydraulic	14
No. 1 SAS OFF	Miscellaneous	15
No. 2 SAS OFF	Miscellaneous	15
Fwd Cyclic Trim Actuator Position Limit	Miscellaneous	15
Aft Cyclic Trim Actuator Position Limit	Miscellaneous	15
Right Aft Landing Gear Phase Limit	Miscellaneous	15
Heater Output Temperature Limit	Miscellaneous	15
ADVISORIES		
AC External Power Connected	Electrical	16
DC External Power Connected	Electrical	16
Parking Brake On/Off	Miscellaneous	16
Cargo Hook Open/Closed	Miscellaneous	16
APU On/Off	Miscellaneous	16

The algorithms which shall be used to determine the presence of these fault conditions are contained in Appendix II. Note that for each fault there is a provision for disabling or "turning off" the algorithm, using and ENABLE discrete, which is received via the 1553B bus (see Table II). The net effect to the system operator of this bit being set low shall be that the system appears to not recognize any new (unacknowledged) fault conditions, nor to remember any pre-existing (acknowledged) faults. Also contained in Appendix II are the algorithms for various time-out faults. These faults are triggered when a parameter stays too long in a time limited operating range. These faults apply to the rotor (only one space separates these two words) rpm, torque and PTIT (or TGT) parameters, as specified in the applicable sections of Appendix I. As indicated in Appendix II, the system implements timers or clocks (CLK) to determine these time out faults. The operation of the clocks shall be as specified in Appendix II.

3.2.1.2.3.2 Fault Display. When it has detected a fault, the EMMADS shall display the subsystem (Format) to which the fault applies, a shown in Table VI. (All faults detectable by this system apply to the engine subystem - Format 2). Within the format, the following symbology rules shall be applied:

a. Parameter symbology associated with unacknowledged faults shall be flashed.

b. Analog scale indicators (bars/pointers) shall be oversized and filled in (as specified in 3.2.1.2.1.2) when that parameter is part of a fault condition (single or multiple parameter faults). This applies to both acknowledged and unacknowledged faults.

In addition to the above, the system shall also display a message capsule in conjunction with any unacknowledged Warning type faults, in the Warning Message Area of the display. The message corresponding to the highest priority unacknowledged Warning shall be enclosed by a heavy box, the possible positions of which are shown in Figure 2. Note these boxes can only be drawn in the top message row. If more than one message is associated with a given Warning, a box shall enclose each applicable message. This system shall utilize only the top message row of the Warning Message Area. The messages to be used with the Warnings that this system can detect are indicated below:

Warning	Message
Eng 1 Failure	E N G 1 O U T
Eng 2 Failure	E N G 2 O U T
Eng 1 and 2 Failure	(Display both of the above simultaneously)
Rotor RPM Limit	R T R L M T

The first message above shall be positioned in the top left message capsule area, the second in the top right area and the last in the top center area.

In the top left area of the display reserved for fault cues (see Figures 2 and 3.1), the word "ENG" shall be displayed whenever the system detects a fault associated with the engine subsystem. It shall be flashing if an unacknowledged fault is present.

In the lower right portion of the Dedicated Status Area, the Time Parameter Limit Clock (Figure 3.1) shall be running whenever one of the time-out fault clocks discussed in Section 3.2.1.2.3.1 is running. Time shall be displayed in minutes and seconds. If more than one clock is running, the one with the least time remaining shall always be displayed, unless a time-out fault occurs. In this case the clock will have counted down to 0 and now will be counting up. The displayed time shall remain at 00:00 so long as the clock continues to run (related time-out fault will stay active - see Appendix II). Acknowledging the time out fault shall cause the display to shift to the clock with the next lowest amount of time remaining, not associated with the same parameter. The Parameter Label Area, just below the clock, shall display that parameter name associated with the displayed clock. The labels (names) used shall be RTR, TRQ1, TRQ2, TGT1 and [illegible] for rotor rpm, Engine 1 and 2 torque and Engine 1 and 2 TGT clocks respectively. In the event a time out fault occurs, the label shall flash.

3.2.1.2.3.3 Fault Acknowledgement. The system shall be able to receive fault acknowledgement via the 1553B bus (Acknowledge bit, PDWD4, Table II) and alternatively via the MLDS. When any unacknowledged fault exists, the system shall change the MLDS that normally bears the "ENG DATA" legend to read "ENG ACK". In addition, if any unacknowledged Warnings exist, the system shall cause the MLDS that normally reads "CHCK LSTS" to have the label

"WARN ACK". Actuation of the "ENG ACK" MLDS shall have the same effect as receiving the PDWD4 Acknowledge command.

The fault acknowledge shall be treated as a momentary input, i.e. the acknowledge command shall be interpreted as active for only one complete iteration of the fault detection algorithms in the digital processor. Thereafter, the acknowledge command must be deactivated (e.g. the "ENG ACK" MLDS must be released) before it can again be sent to the DP.

Each Warning must be acknowledged separately (unless the "WARN ACK" MLDS is used, as described later in the section). Upon receipt of an acknowledge to a Warning, Format 8 shall be displayed with the emergency action checklist applicable to that Warning. At the same time the message capsule(s) for that Warning shall be removed from the display, as indicated in Section 3.2.1.2.3.2. An acknowledgement for the checklist is also required, upon which the display shall return to Format 1 unless other faults remain.

When only Cautions/Precautions are displayed, a single acknowledge command shall be required to acknowledge all the faults. The display will then revert to Format 1.

Depressing the "WARN ACK" MLDS shall cause all displayed Warnings to be simultaneously acknowledged, with no checklists displayed. To acknowledge the checklist(s), the "ENG PROC" MLDS must then be selected, as specified in 3.2.1.2.2. Depressing the "ENG PROC" MLDS shall cause the highest priority, unacknowledged emergency action checklist to be displayed (Format 8) and shall also cause that MLDS to once again be labeled "ENG ACK". Each acknowledge command then received shall result in the acknowledgement and removal of each such checklist from the display until finally the last checklist is acknowledged. This shall cause the MLDS legends to revert to the (normal) Subsystem Information level (Figure 4a)

and the display to return to Format 1. Thus, whenever the acknowledge function is needed (fault or emergency action checklist acknowledgement) the MLDS "ENG ACK" is provided by the system.

An example to illustrate some of the elements of Fault Commanded operations follows. With no active faults, the DU is represented as shown in Figure 6.1. The system reacts to a No. 2 Engine failure as shown in Figure 6.2. The fault is acknowledged and the checklist is displayed in Figure 6.3. Finally acknowledging the checklist causes the MLDS legends to return to the Subsystem Information level and Format 1 is displayed as shown in Figure 6.4.

3.2.2 Physical Characteristics. The physical characteristics of the equipment shall reflect thoughtful consideration for the operational and protective enclosure requirements of the hardware elements used. Use of MIL-E-5400P as a guide in equipment design is encouraged. Each separate piece of equipment shall be of a size and weight convenient for handling and transportability.

3.2.2.1 Display. The EMMADS Human Engineering Summary Report shall be utilized as a guide in selecting a suitable display. An active display area size of 5" x 7" is preferred. Minimum size shall be 3.5" x 4.7".

3.2.2.2 Multilegend Display Switches. The EMMADS Human Engineering Summary Report shall be utilized as a guide to MLDS size, spacing, mechanical depression resistance, displacement and surface.

3.2.2.3 Data Entry/Retreival Unit. The DERU shall be hand portable. It shall also be capable of one-handed operation.

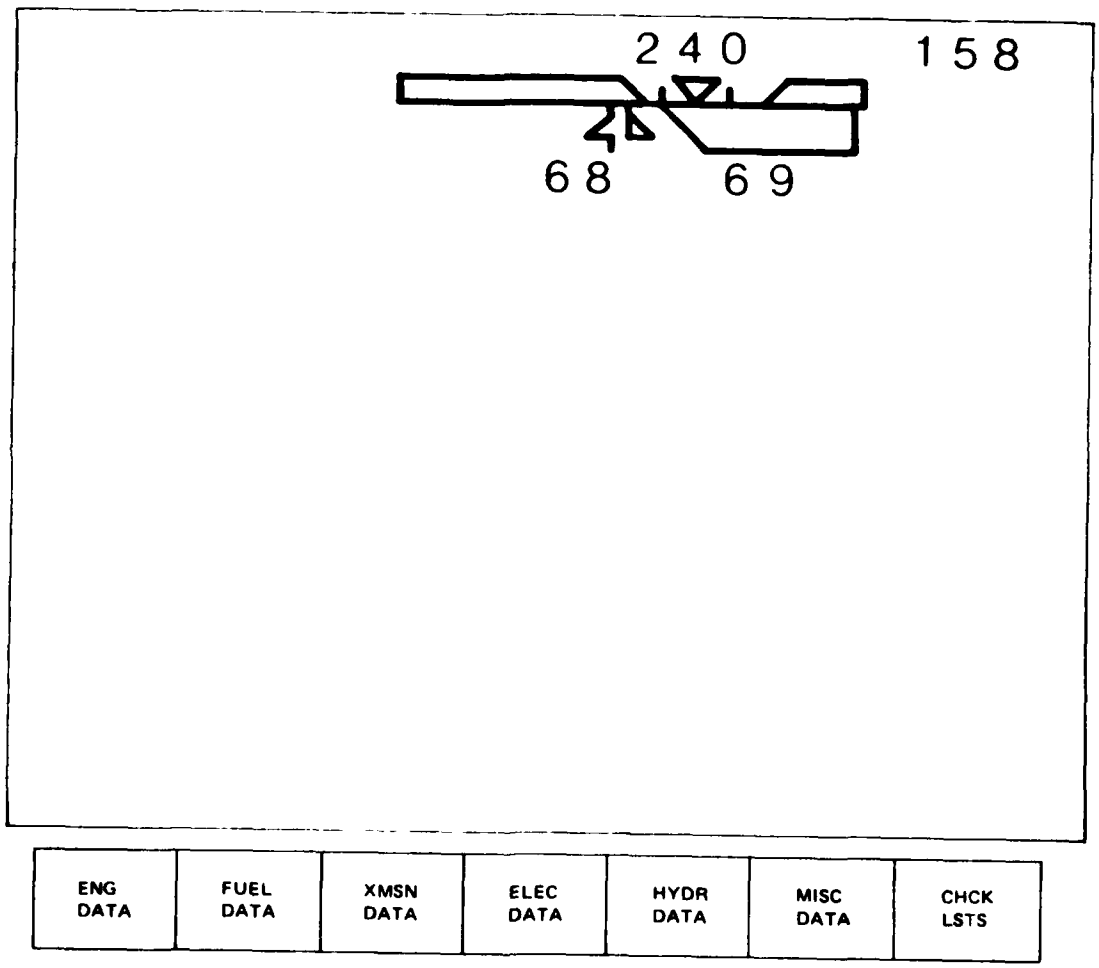


Figure 6.1. Fault Commanded Operations - No Faults Detected

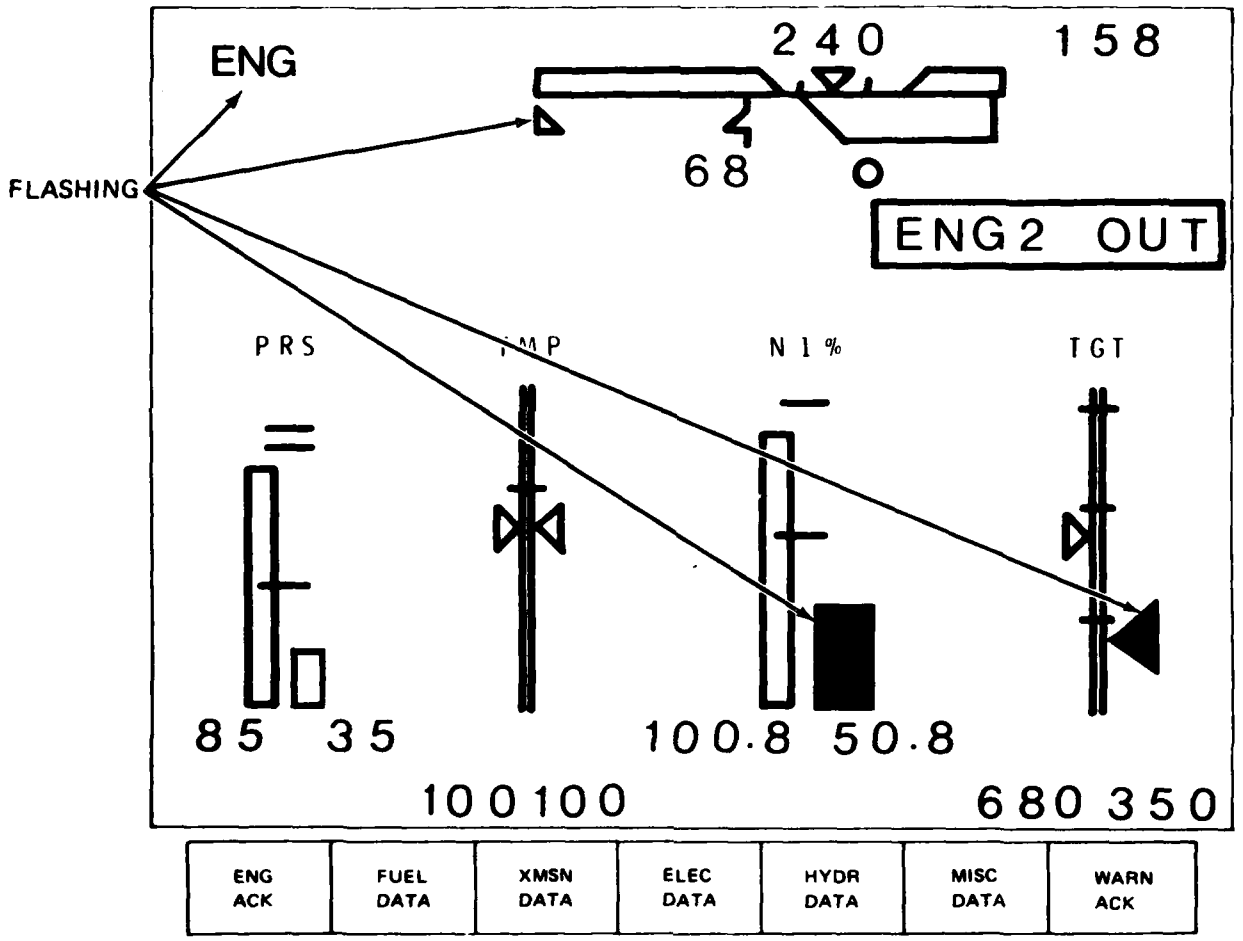


Figure 6.2. Engine 2 Failure (Warning) Detected - Fault Not Acknowledged

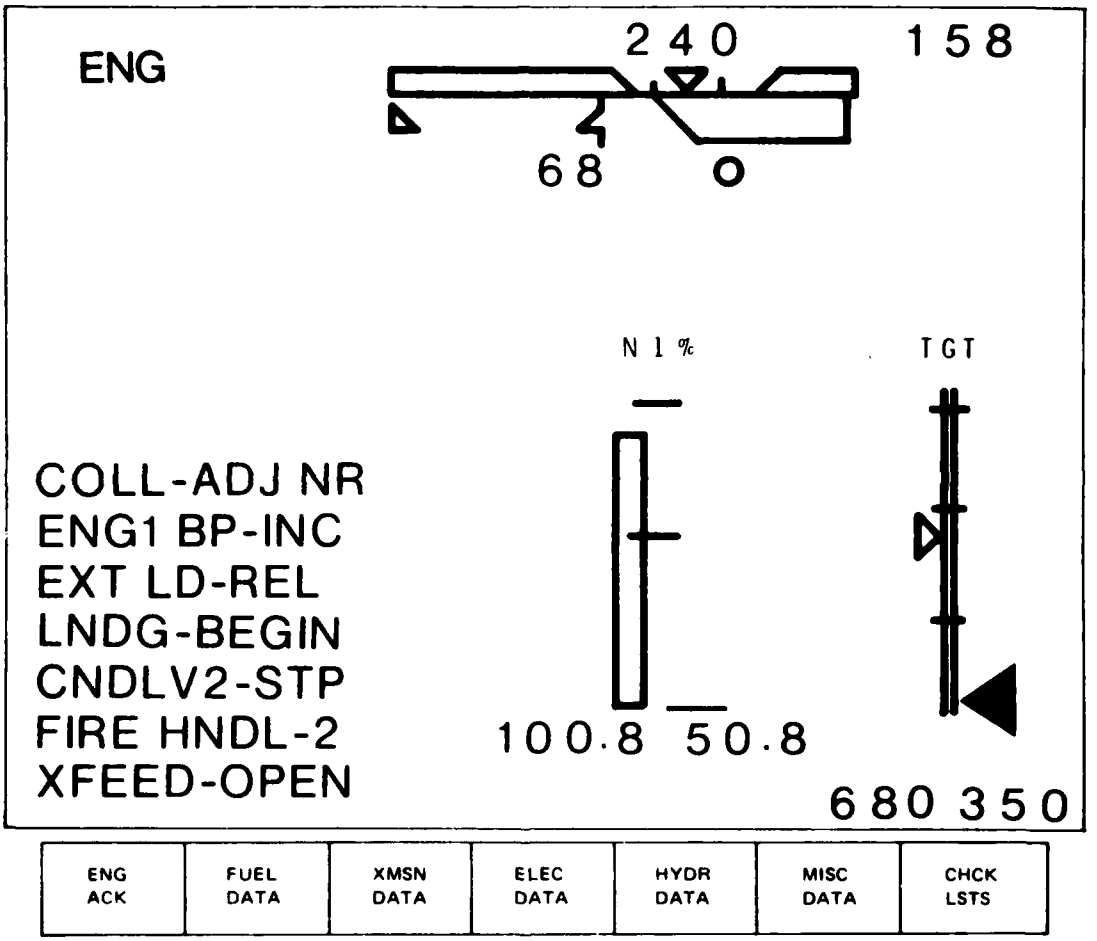


Figure 6.3. No. 2 Engine Failure Acknowledged - Emergency Procedures Displayed

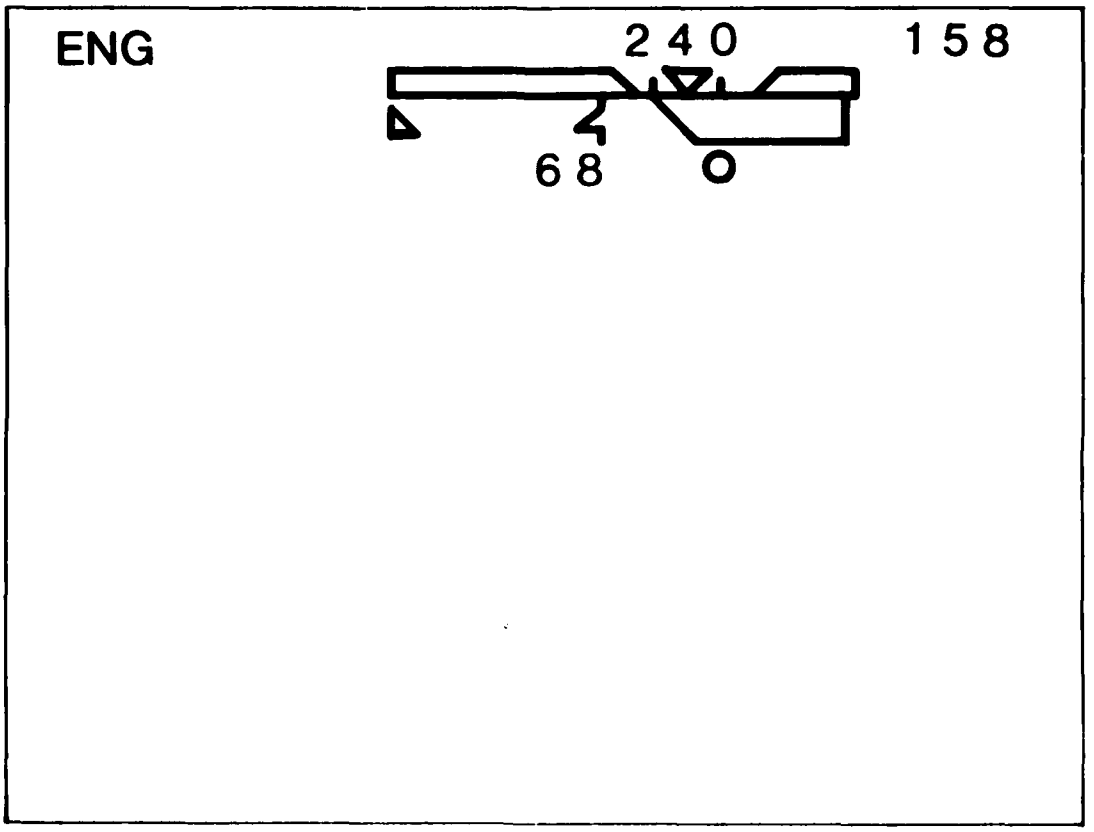


Figure 6.4. All Acknowledgements Completed

4.0 QUALITY ASSURANCE PROVISIONS.

4.1 General. Quality assurance of the EMMADS feasibility model shall be established by satisfactory demonstration of its ability to meet the requirements of Section 3.0 of this specification.

4.1.1 Responsibility for Inspection. Unless otherwise specified by contract or order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in this specification, where such inspections are deemed necessary to assure conformance to prescribed requirements.

4.1.2 Acceptance Test Procedure. Acceptance testing shall be in accordance with the EMMADS Acceptance Test Procedure listed in Section 2.0, except as specified herein. The Government reserves the right to modify said procedure in order to better test the conformance of the system to the requirements of Section 3.0.

4.2 Quality Conformance Testing.

4.2.1 Performance Characteristics. To be tested as detailed below.

4.2.1.1 Major Components. The supplier must demonstrate that all EMMADS major components meet the requirements of Section 3.2.1.1. This may be done in one of the following ways:

a. Submission of a specification sheet (where applicable) which the supplier used as a basis for purchasing the component and which indicates to the Government's

satisfaction that the component meets the applicable performance specification, or

b. Actual component testing.

4.2.1.2 System. Compliance with the system performance characteristics shall be demonstrated through successful completion of the EMMADS Acceptance Test Procedure.

4.2.2 Physical Characteristics. These shall be validated in the applicable section of the EMMADS Acceptance Test Procedure or as in 4.2.1.1(a) above.

5.0 PREPARATION FOR DELIVERY.

Unless otherwise specified by contract or purchase order, preparation for delivery of equipment shall be in accordance with the following:

5.1 Packaging, Packing and Marking. The equipment furnished to this specification shall be packaged and packed in accordance with MIL-STD-1188A and marked in accordance with MIL-STD-129H.

Appendix I

SUBSYSTEM PARAMETER DATA LIST FOR THE CH-47C

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A1

SUBSYSTEM: Engine (T55-L-11D Only)

Sheet No.: 1

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 4)
Eng Gas Producer Speed - NO. 1 (2) ENGINE PERCENT RPM	Circular Dials (2)	0-110	(Maximum)R (See Note)	%	Eng Cond Lever in GROUND, Eng Started	60-63	Normal - continuous	-10-2, pp 2-25, 5-4 & 5-9, 8-7 & 16-1 -23-3, pp 8-1/2 -23-5, p F-64	1
					Eng Cond lever in FLIGHT, Eng Started	65-103 (see note)	Normal - continuous		
						103 (see note)	Maximum - continuous		
Engine Pwr Turbine Inlet Temperature - NO. 1 (2) ENGINE TEMP	Circular Dials (2)	0-1200	(399-770)G (788-927)Y (810)B (860)R (927)R (see note)	°C	Eng Start	0-788	Normal - Transient	-10-2, pp 2-25, 5-4 & 10/11, 8-17 & 21 -23-3, pp 8-11/12 -23-5, p F-65	2
						788-927	Warning - 5 sec to 0 sec (see note)		
						927	Maximum - none allowed		
					Eng Shut-down	0-260	Normal - continuous		
						260-350	Cautionary - Transient		
						350	Maximum - Transient		
					Other than Eng Start	399-770	Normal - continuous		
						770-810	Cautionary - 30 minutes		
						810-860	Cautionary - 10 minutes		
						860	Maximum - 10 minutes		
						927	Maximum - none allowed		

Table: A1 (Engine - Cont'd)

Sheet No.: 2

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 4)
Eng Torque - ENGINE TORQUE PERCENT 1 (2)	Circular Dial w/Two Needles	0-150	(78)R (100)R	%	Single Engine	0-85 @ 245 NR	Normal - Continuous	-10-2, pp 2-25 & 5-3, 9/10 -23-3, pp 8-14/17 & FO-20 -23-5, p F-59	3
						0-89 @ 235 NR			
						0-91 @ 230 NR			
						85-97 @ 245 NR	Cautionary - 30 minutes		
						89-100 @ 235 NR			
						91-100 @ 230 NR			
						97-100 @ 245 NR	Cautionary - 10 minutes		
						100 @ 230-235 NR			
						100-138	Warning - Transient (10 seconds)		
						138	Maximum - 10 seconds		
					Dual Engine	0-78	Normal - continuous		
						78-100	Cautionary - Transient (10 seconds)		
						100	Maximum - 10 seconds		
Eng Bearing No. 2 Oil Pressure - NO. 1 (2) ENGINE OIL PRESS	Circular Dials (2)	0-200	(20)R (35-90)G (110)R	psi	45% < N_1 <70% (See Note)	20	Minimum - continuous	-10-2, pp 2-25 & 5-4 -23-3, pp 8-5/6 -23-5, p F-62	4
					70% ≤ N_1 <95%	35	Minimum - continuous		
						35-50	Normal - continuous		
					95% ≤ N_1	50	Minimum - continuous		
						50-90	Normal - continuous		
					All	110	Maximum - unspecified		

Table: A1 (Engine - Cont'd)

Sheet No.: 3

PARAMETER NAME-INDICATOR LABEL	INDICATOR				OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 4)
	TYPE	RANGE	MARKINGS	UNITS		CONDITION	CONDITION TYPE - DURATION		
Engine Oil Temperature - NO. 1 (2) ENGINE OIL	Circular Dials (2)	-70-150	(138)R	°C	All	138	Maximum - unspecified	-10-2, pp 2 25 & 5-4 -23-3, p 8-7 -23-5, p F-60	5
Engine Oil Level - OIL LOW NO. 1 (2) ENG	Caution Lgts (2)		Amber	qts	All	≤ 2.0 qts useable in the reservoir	Cautionary - unspecified	-10-2, pp 2-25 & 70 -23-2, p 4-155 -23-5, p F-71	6
Eng Bearing & Accessory Gearbox Integrity - NO. 1 (2) ENG CHIP DET	Caution Lgts (2)		Amber	--	All	Sensor grounded by metal particles from eng bearings and/or gearing	Cautionary - unspecified	-10-2, pp 2-26 & 71 -23-5, pp F-168/170	7
Eng Condition Lever Position/ Gas Producer Position Signal Error - NO. 1 (2) ENG N1 CONT	Caution Lgts (2)		Amber	--	All	Error signal detected between engine condition lever position & gas producer actuator position, or eng condition lever is not in one of the detents	Cautionary - unspecified	-10-2, pp 2-23 & 71 -23-2, pp 4-179/181 -23-5, p F-89	8

Table: A1 (Engine - Cont'd) Sheet No.: 4

NOTES:

1. Reference the Operator's Manual, p 5-9, paragraphs 5-23 and 5-24, the actual upper limit of the normal N_1 speed range is obtained from the engine test log or the engine overhaul data plate. A cautionary limit is implied as being set from this maximum power speed up to 2% above this speed. However, the duration is only vaguely specified (i.e. "limit the time spent in that range"). The 103% figure was used since it is described as a maximum allowable N_1 speed for Table 5-2. The N_1 speed sensor is a tachometer generator (G704 - 3 phase ac type) which supplies a voltage to the indicator (M121 or M118) where the frequency is proportional to the compressor speed.

2. Figure 5-5 of the Operator's Manual indicates that for engine start, with a PTIT at or above 788°C, the allowable time versus temperature equation is PTIT = -27.8t + 927 where t is in seconds and PTIT is in °C. There is no specified relationship for PTIT vs t below 788°C on engine start. Also, although not specifically stated, it is presumed that the above equation applies for acceleration and time limited operations between 927°C and 860°C. Sensors are 10 chromel-alumel thermocouple probes, connected to the indicators (M123), which are millivoltmeters. Also included in the circuit is a variable (spool) resistor (R101) which is set between 21.95 and 22.05 ohms.

3. The Operator's Manual specifies 78% and 100% as the transmission steady state torque limits for dual and single engine operations, respectively, and 100% and 130% as the corresponding transient limits. Sensors consist of a primary winding on the engine output shaft which rotates inside of a torquemeter head containing a primary and two secondary windings. A 2KHz reference signal applied to the torquemeter head assembly couples to a secondary winding while the rotating shaft induced signal is coupled to the other secondary winding. A junction box at each engine rectifies these voltages producing a difference voltage which is sensed and displayed as percent torque by the pilot's and copilot's indicators (M139 and M132).

4. Sensors are synchros (MT 710) which utilize 26 vac to produce a signal proportional to oil pressure, driving the No. 1 (2) engine indicators (M114 and M117). The operating mode for 20 psi minimum oil pressure is stated in the Operator's Manual as "ground idle". Normal N_1 speed at ground idle is 60%-63% but this leaves undefined the 0-60% and 63%-70% ranges. Thus 45%-70% N_1 was chosen to apply the 20 psi minimum oil pressure to as a range which would include the ground idle state with nearly all possible N_1 speeds. Less than 45% would be a "don't care" condition since this would be a result of shutdown or a hung start.

5. Sensors are bimetalic thermistor type probes which change resistance linearly with temperature. The power to operate the No. 1 (2) indicators (M112 and M115) comes from the 28 VDC Primary Bus.

6. Sensors are level detecting micro switches in each oil tank which are grounded when the tripping threshold is reached. The signals are routed to the caution panel through connector pins F & H. If oil consumption exceeds 2 qts/hour, write up required (-10-2, p 2-24).

7. Sensors are three magnetic plugs positioned in the accessory gearbox sump, in the No. 2 bearing external oil return line and in the No. 4 & 5 bearings external oil return line. The plugs are likely grounded by metal chips, thus grounding pins A & B of the caution panel connector.

8. Sensors consist of a servo amplifier card to detect the position errors between the synchros in each engine control system. Additional sensors are the detent detecting microswitches for each engine condition lever. The error signal is sent to pins P173 E and X on the caution panel.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A2

SUBSYSTEM: Fuel

Sheet No.: 1

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 2)
Fuel Quantity in the Aft, Main and Fwd Tanks on both the Left & Right Sides - FUEL QUANTITY L(R) AFT, MAIN, FWD	Circular Dial w/Pointer & Selector Switch	0-2300	None	lbs	All	0-(320-420)	Cautionary - unspecified	-10-2, pp 2-31/32, 53, 56, 71 & 75 -23-3, p FO-24 -23-5, p F-69	1
						(320-420)-6804	Normal - continuous		
FUEL QUANTITY TOTAL	No pointer indication but continuous digital readout on dial. Independent of selector sw position.	0-9999							
L(R) FUEL LOW	Caution Lgts (2)	--	Amber			<(320-420)	Cautionary - unspecified		2
Engine Fuel Line Pressure - L(R) FUEL PRESS	Caution Lgts (2)	--	Amber	psi	Pressure altitude ≤6000'	<10	Cautionary - unspecified	-10-2, pp 2-31/32 & 70 -23-4, p FO-33 -23-5, p F-147/148	3
					Pressure altitude >6000'		Warning - none allowed		
Auxiliary Tank Fuel Boost Pump Pressure - AUX PRESS LEFT (RIGHT) SIDE	Press to Test Caution Lgts (2)	--	Amber	psi	All	<(9-11)	Cautionary - unspecified	-10-2, pp 2-32 -23-4, p FO-33 -23-5, p F-149	4

Table: A2 (Fuel - Cont'd) Sheet No.: 2

NOTES:

1. Sensors are ten capacitance type probes, three in each main tank and one in each auxiliary tank. The three probes in each main tank are wired in parallel, with one of the resulting twin lead-outs from each tank wired to the selector switch, while the remaining lead-outs are tied together at the indicator. For the auxiliary tank probes, one line from each probe is connected to the selector switch and the other lines are tied together at the indicator. The cautionary range specification is based on the low fuel caution light threshold and not on a dial marking. Note that tank capacities are all different, even for like tanks (TM55-1520-227-10-2, p 2-75).

2. Sensors are thermistor bead type units (A608 - Right and A609 - Left) at the lower end of the center fuel quantity probes (MT 604 and MT 609) in the main tanks. The signal is routed to the thermistor control unit (A142) which signals the caution panel when a main tank is down to about 20% of its capacity (see reference quoted in Note 1 above).

3. Sensors are pressure switches between the aft auxiliary tank and the engine fuel valves. The switch closes a path from the caution panel to ground when the low pressure threshold is reached. Operation above 6000' pressure altitude with the light on is likely to cause an engine flameout.

4. Sensors are four pressure switches, one for each auxiliary boost pump. The pressure switches on the same side of the aircraft provide a path to ground for the same light, but through the separate auxiliary boost pump switches (via a separate set of contacts in each switch) for that side. Thus, the pressure loss may be tracked to the specific line by alternately turning ON and OFF the Fwd and Aft Auxiliary Boost Pump switches for the affected side. Since power to the lights is through breakers which protect the pump relay power lines (see Table A5) a tripped circuit breaker would cause a fuel pressure loss with no light to show such loss.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A3

SUBSYSTEM: Powertrain

Sheet No.: 1

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	PARAMETER OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 3)
Rotor Speed - RPM ROTOR	Circular Dial	0-290	(214)R (214-232)Y (232-250)G (250-255)Y (255)R (261)R	RPM	Ground Ops, Min Beep, Eng Cond Lvrs @ FLIGHT	214	Minimum - continuous	-10-2, pp 2-45, 5-2, 3 & 9 -23-2, p 4-51 -23-3, pp 8-63 & 64 -23-5, p F-63	1
					Powered Flight	214-232	Cautionary - unspecified (see note)		
						232	Minimum - continuous		
						235-245	Normal - continuous (245 rpm if gross weight >40,000 lbs)		
						250	Maximum - continuous		
						251-255	Maximum (power turbine limit) - 5 minutes		
						256-262.5	Maximum (power turbine limit) - 5 seconds		
					Autorotation	232-261	Normal - continuous		
						261-265	Cautionary - transient		
						265	Maximum - transient		
Forward, Aft, Combining & Engine Gearboxes Oil Pressure - XMSN OIL PRESS	Circular Dial w/Selector Switch	0-100	(20)R (20-90)G	psi	60% $\leq N_1$ <63%	10	Minimum - continuous	-10-2, pp 2-41/43, 70 & 5-5 -23-3, pp 8-50/54 & FO-22 -23-5, p F-53 (Also 55-1500-210-MTF p 2-76)	2
					N_1 >63%	20	Minimum - continuous		
						20-90	Normal - continuous		
XMSN OIL PRESS	Caution Lgt	--	Ambr		All	$\leq$20 $\pm$2	Cautionary - unspecified		

Table: A3 (Powertrain Cont'd)

Sheet No.: 2

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 3)
Forward, Aft, Combining & Engine Gearboxes Oil Temp - XMSN OIL TEMP	Circular Dial w/Selector Switch	-70-150	(130)R (130-140)Y (140)R	°C	All	<130	Normal - continuous	-10-2, pp 2-42/43, 70/71, 5-5 & 9-9 -23-2, pp 6-173 & FO-12/13 -23-3, pp 8-57/62 -23-5, pp F-51/53 & 169	4
						130	Maximum (all but engine gearboxes) - continuous		
						130-140	Cautionary (engine gearboxes only) - 1 hour		
						140	Maximum (engine gearboxes only) - 1 hour		
XMSN OIL HOT	Caution Lgt	--	Amber			>130	Cautionary - unspecified (see above limits)		5
NO. 1 (2) ENG XMSN HOT	Caution Lgts (2)	--	Amber			>190	Cautionary - unpsecified		6
Forward, Aft & Combining Gearboxes & Aft Vertical Shaft Thrust Bearing Integrity - XMSN CHIP DET	Caution Lgt	--	Amber	--	All	Sensor contacts grounded by metal particles from geargoxes or thrust bearing	Cautionary - unspecified	-10-2, pp 2-43 & 71 -23-2, pp 6-129/132, 135/137, 155 & FO-12/13 -23-5, pp F-168/170	7

Table: A3 (Powertrain - Cont'd) Sheet No.: 3

NOTES:

1. Sensor is identical to that used for the gas producer speed indicating system and is located on the Forward Transmission. The indicator is a dual pointer type, with an inner scale range of 0-130 RPM and an outer scale range of 130-290 RPM. Note that the normal rpm range during autorotation is based on the minimum green arc rpm and the specification by the Operator's Manual (p 5-2) of 261 rpm as the "maximum continuous rotor speed during autorotation". Note that although the range 214-232 is marked as a cautionary range, it is probably meant to be a transient range which is also normal for ground operations.

2. Sensor is a variable reluctance transformer which supplies a differential voltage, proportional to the sensed pressure, to selector switch circuitry associated with the indicator.

3. Sensor is a switch which is built into the oil pressure indicator (M103). The switch grounds the sensing lead from the caution panel when the threshold is reached for the gearbox being monitored by the oil pressure indicator selector switch. When the selector switch is in scan, the lowest pressure is displayed and the caution light will act as a warning device for whichever gearbox oil pressure goes below the minimum allowable.

4. Sensors are electrical resistance type temperature bulbs, calibrated to provide 1200 ohms at 0°C. They are incorporated into a wheatstone bridge where the resulting voltage inbalance drives a motor which moves the wiper arm of the bridge's variable resistor as well as the indicator pointer. The sensor used in the bridge depends on the position of the XMSN OIL TEMP selector switch. A faulty sensor is indicated by the pointer going above 150° when the selector switch is set to SCAN or below -70° when the switch is set to the faulty sensor's position.

5. Sensor is a switch in the temperature indicator described above. Again the light will only indicate an excessive temperature condition for the gearbox designated by the selector switch.

6. The system is installed only on aircraft #74-22276 and subsequent. Sensors are thermoswitches which are part of a combined chip detector/temperature sensor assembly. The sensing is most likely accomplished by grounding the lead from the caution panel for the affected caution capsule.

7. Sensors are bayonet-type electrical contact/magnetic plug combination detectors which provide a grounding path when ferrous type particles bridge the contacts. This ground is sensed by the caution panel circuitry, which lights the caution capsule.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A4

SUBSYSTEM: Hydraulic

Sheet No.: 1

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 2)
Flight Control Hydraulic Pressure - NO. 1 (2) BOOST	Circular Dials (2)	0-4000	(2500)R (2500-3200)G (3200)R	psi	All	2500	Minimum - continuous	-10-2, pp 2-40, 70 & 5-8 -23-3, pp 7-20, 8-47/50 & FO-14 -23-5, p F-50	1
						2500-3200	Normal - continuous		
						>3200	Maximum - continuous		
NO. 1 (2) HYD BOOST OFF	Caution Lgts (2)	--	Amber			<(2050-1950)	Cautionary - unspecified		2
Utility Hydraulic System Pressure - UTILITY	Circular Dial	0-4000	(2500)R (2500-3400)G (3400)R			2500	Minimum - continuous	-10-2, pp [illegible] -23-3, p F[illegible] -23-5, p F-[illegible]	3
						2500-3400	Normal - continuous		
						3400	Maximum - continuous		

Table: A4 (Hydraulic - Cont'd) Sheet No.: 2

NOTES:

1. Sensors are 26 VAC, 400 Hz synchro units driving similar units for indicators. 200 psig fluctuations possible with rapid control movements. Normal tolerance ±50 psig.

2. Sensors are pressure switches which ground the sensing lines from the caution panel. Power to the capsules is provided via the CAUTION LGTS circuit breaker. The switching threshold used is from the fourth page reference, versus the 2000-2100 psi threshold given in the first page reference.

3. Sensor is the same type as in Note 1 above. Normal tolerance ±50 psig.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A5

SUBSYSTEM: Electrical

Sheet No.: 1

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Generator Output Suitability - NO. 1 (2) GEN OFF	Caution Lgts (2)	--	Amber		All	Volts out >132 vac (3 seconds), volts out <100 vac (3 phse aver., 5-7 seconds), freq. out <345 or feeder fault >33.3 amps. Generator disconnected from the Primary or Secondary bus respectively	Cautionary - unspecified	-10-2, pp 2-57 & 70 -23-3, pp 9-18/20, & FO-28 & 30 -23-5, p F-179	1
B Phase Generator Load - NO. 1 (2) GEN	Circular Dials (2)	0-1.5	--	Load Fract	Generator on line	0-1.0	Normal - continuous	-10-2, p 2-13, 56 -23-3, p 8-67 & FO-28 -23-5, p F-179	2
						1.0 - 1.5	Cautionary (overdraw) - unspecified		
					Generator off line	Positive or Negative Load	Cautionary - unspecified		
AC External Pwr Connection & Suitability - AC EXT PWR ON	Caution Lgt	--	Amber	--	All	External power is connected to the AC Primary Bus	Advisory - unspecified	-10-2, pp 2-57 & 70 -23-3, pp 9-18/20, & FO-28 & 30 -23-5, p F-179	3
DC Power Supply (Rectifier) Load - NO. 1 (2) RECT	Circular Dials (2)	0-1.5	--	Load Fract	Rectifier on Line	0-1.0	Normal - Continuous	-10-2, pp 2-13 & 57 -23-3, pp 8-65/66 -23-5, p F-135	4
						1.0 - 1.5	Cautionary (overdraw) - unspecified		
					Rectifier off line	Positive or Negative Load	Cautionary - unspecified		
DC Power Supply Output - NO. 1 (2) RECT OFF	Caution Lgts (2)	--	Amber	--	All	Output voltage of respective power supply less than that of bus it supplies. Power supply disconnected from bus	Cautionary - unspecified	-10-2, pp 2-57 & 70 -23-3, pp 9-1/3, 11 & FO-26 -23-5, p F-135	5

Table: A5 Electrical (Cont'd)

Sheet No.: 2

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	PARAMETER OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
DC External Pwr Connection and Suitability - DC EXT PWR ON	Caution Lgt	--	Amber	--	All	External power is connected to the DC Primary Bus	Advisory - unspecified	-10-2, pp 2-57 & 71 -23-3, pp 9-2/3, 12 & FO-26 -23-5, p F-135	6
Generator No. 2, Bus Tie & Aux. Bus Relays (K103, K105 & K107) Power Overdraw - AC BUS CONT	Tripped Crct Brkr (CB 110)	--	5	Amps	Both generators on line	>5 amps to all relays from the 28 VDC Primary Bus			
					Eng. Start	>5 amps to relays K105 & K103 only. Same power source.		-10-2, pp 2-54 & 59 -23-3, pp FO-28 & 30 -23-5, p F-179	
					Gen. No. 2 off line	>5 amps to relays K107 & K105 only. Same power source			
115 VAC Primary Bus Power Overdraw - A PH FDR	Tripped Crct Brkrs (CB 1031, CB 1033 & CB 1035)					>10 amps through respective breaker set from the 208 VAC Primary Bus, A phase			7
115V AC PRI BUS FEEDERS	Tripped Crct Brkrs (CB 199, CB 1001 & CB 1003)								
115 VAC Secondary Bus Pwr Overdraw - B PH FDR	Tripped Crct Brkrs (CB 1015, CB 1017 & CB 1019)		10	Amps	All	>10 amps through respective breaker set from the 208 VAC Secondary Bus, B phase		-10-2, pp 2-52/53 & 55 -23-5, p F-185	
115V AC SEC BUS FEEDERS	Tripped Crct Brkrs (CB 1005, CB 1007 & CB 1009)								8
26 VAC Instrument Bus Pwr Overdraw - 26 VAC FDR	Tripped Crct Brkrs (CB 1041, CB 1043 & CB 1045)					>10 amps through respective breaker set from the output winding of the 115/26V transformer			
26 VAC INSTR BUS FEEDERS	Tripped Crct Brkrs (CB 1012, CB 1014 & CB 1016)								

Table: A5 Electrical (Cont'd)

Sheet No.: 3

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
115/26V Transformer Primary Pwr Overdraw - 115-26V XMFR	Tripped Crct Brkr (CB 1039)		5	Amps	All	>5 amps to the primary winding from the 208 VAC Primary Bus (phase unknown)		-10-2, pp 2-52/53 & 55 -23-5, p F-185	
DC Power Supply Pwr Overdraw - XFMR RECT NO. 1 (2)	Tripped Crct Brkrs (CB 1011 & CB 1013)		35			>35 amps to the respective pwr supply from the 208 VAC Primary and Secondary Busses respectively			
Bus Tie & Radio Bus Tie Relays (K112 & K116) Pwr Overdraw - DC BUS CONT NO. 1 (2)	Tipped Crct Brkrs (CB 1024 & CB 1090)		5		#1 Pwr Supply off, #2 on	>5 amps to relays through CB 1090, from the 28 VDC Secondary Bus			
					#2 Pwr Supply off, #1 is on	>5 amps to relays through CB 1024 (unless an engine is being started) from the 28 VDC Primary Bus			
Reverse Current Relays (K126 & K128) Volt Relay Coil, Bias Coil & Main Cont Coil Power Overdraw - REV CUR CO NO. 1 (2)	Tripped Crct Brkrs (CB 1018 & CB 1020)		15		All	>15 amps to relays of respective RCR (K126 or K128) from the output of the respective power supply		-10-2, pp 2-54, 56 & 59 -23-3, pp 9-10 & FO-26 -23-5, pp F-135 & 141	
External Power (K114) & External Power Control (K122) Relays Power Overdraw - DC EXT PWR CONT	Tripped Crct Brkr (CB 1022)					>15 amps to the relays from the DC External Power source			

Table: A5 Electrical (Cont'd)

Sheet No.: 4

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Overhead Panel Battery Bus Pwr Overdraw - BTRY BUS FEEDER	Tripped Crct Brkr (CB 1026)		15	Amps	All	>15 amps to the bus from the DC Circuit Breaker Box Battery Bus		-10-2, pp 2-54, 56 & 59 -23-3, pp 9-10 & FO-28 -23-5, p F-135 & 141	8
Overhead Panel 28 VDC Primary Bus Power Overdraw - 28 VDC PRIMARY BUS FEEDERS	Tripped Crct Brkrs (CB 1046, CB 1048 & CB 1050)		35			>35 amps through the respective breaker set, from the DC circuit breaker box 28 VDC Primary Bus			
28V DC PRI BUS FEEDERS	Tripped Crct Brkrs (CB 1034, CB 1036 & CB 1038)								
Overhead panel 28 VDC Secondary Bus Power Overdraw - 28 VDC SECONDARY BUS FEEDERS	Tripped Crct Brkrs (CB 1028, CB 1030 & CB 1032)		50			>50 amps through the respective breaker set from the DC circuit breaker box 28 VDC Secondary Bus			
28V DC SEC BUS FEEDERS	Tripped Crct Brkrs (CB 1040, CB 1042 & CB 1044)								
Engine Condition Relays (K503 & K505) and Beep Trim Actuators Pwr Overdraw - ENG TRIM DC NO. 1 (2)	Tripped Crct Brkrs (CB 130 & CB 167)		5			>5 amps to applicable relay and respective engine beep trim actuator from the 28 VDC Primary Bus		-10-2, pp 2-23, 56 & 59 -23-2, pp 4-190/192 & FO-11	

Table: A5 Electrical (Cont'd)

Sheet No.: 5

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	PARAMETER OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Engine Power Turbine Control Box & Actuator Pwr Overdraw - ENG TRIM AC NO. 1 (2)	Tripped Crct Brkrs (CB 132 & CB 171)				Normal Engine Trim On	>5 amps to respective engine systems from the 115 VAC Primary Bus		-10-2, pp 2-23, 56 & 59 -23-2, pp 4-190/192 & FO-11	
Engine Power Turbine Actuator Pwr Overdraw - EMERG ENG TRIM	Tripped Crct Brkr (CB 169)		5	Amps	Normal Eng Trim OFF, No. 1 (2) EMERG ENG TRIM switch actuated	>5 amps to respective actuator from the 28 VDC EMER BUS			
Engine Start Valve (L707), Utility System Start Valve (L721), Relays K104 & K108 Pwr Overdraw - NO. 1 (2) ENG START	Tripped Crct Brkrs (CB 122 & CB 163)				Eng 1 or 2 start button depressed (respectively)	>5 amps to systems from the 28 VDC Primary Bus			
No. 1 (2) Eng Start Fuel Solenoid & Ignition Exciter Pwr Overdraw - IGNITION ENG NO. 1 (2)	Tripped Crct Brkrs (CB 124 & CB165)		10		Same as above but also respective eng condition lever @ GROUND, ignition lock, start fuel & ignition switches all ON	>10 amps to solenoids (with respective switches ON) from the 28 VDC Primary Bus		-10-2, pp 2-22, 24, 56 & 59 -23-2, pp 4-158/159 & FO-9/10 -23-3, pp 7-142/143 & FO-15 -23-5, pp F-83 & 121	

Table: A5 Electrical (Cont'd)

Sheet No.: 6

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SM 21)
Ground Idle Pwr Interlock Relay & Gas Producer Control Relay Normal Power Overdraw - ENG COND CONT NO. 1 (2)	Tripped Crct Brkrs (CB 1087 & CB 1094)		5	Amps	Respective eng condition lever in GROUND position (interlock sw closes)	>5 amps to system from the 28 VDC Primary Bus		-10-2, pp 2-22/23, 56 & 59 -23-2, pp 4-179/181 & FO-9/10 -23-5, p F-91	
Thrust Control Magnetic Brake Pwr Overdraw - THRUST BRAKE	Tripped Crct Brkr (CB 107)				All	>5 amps to brake from the 28 VDC Primary Bus		-10-2, pp 2-33, 56, 58 & 59 -23-3, p 9-95 -23-5, p F-48	9
Fairing Hot Air Valve Power Overdraw - ENG NO. 1 (2) ANTI-ICE	Tripped Crct Brkrs (CB 145 & CB 147)					>5 amps to the respective valves (type 114PS208-3) from the 28 VDC Primary Bus		-10-2, pp 2-20, 56 & 59 -23-2, pp 4-134 & 135	10
Engine Power Supply Power Overdraw - NO. 1 (2) ENG TORQUE DC	Tripped Crct Brkrs (CB 1077 & CB 1079)					>5 amps to the respective power supply which provides the 2 KHz reference signal to the torque meter head assembly. Power is from the 28 VDC Primary Bus		-10-2, pp 2-52, 53 & 59 -23-3, p FO-20 -23-5, p F-59	11
Engine Torquemeter Indicator Pwr Overdraw - NO. 1 (2) ENG TORQUE AC	Tripped Crct Brkrs (CB 1073 & CB 1075)					>5 amps to the co-pilot's & pilot's indicators, respectively, from the 115 VAC Primary Bus			

Table: A5 Electrical (Cont'd)

Sheet No.: 7

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Engine Oil Pressure Systems Pwr Overdraw - PRESS IND ENG OIL	Tripped Crct Brkr (CB 116)					>5 amps to the transmitters & indicators from the 26 VAC INSTR BUS		-10-2, pp 2-25, 53 & 56 -23-3, p 8-6 -23-5, p F-62	
Engine Oil Temperature Indicators Pwr Overdraw - ENG OIL TEMP	Tripped Crct Brkr (CB 121)					>5 amps to the indicators from the 28 VDC Primary Bus		-10-2, pp 2-56 & 59 -23-3, p 8-10 -23-5, p F-60	
Main Fuel Boost Pump Relays (K411 & K413) Pwr Overdraw - FUEL PUMP CONTROL L FWD (AFT)	Tripped Crct Brkrs (CB 1052 & CB 1047)					>5 amps to relays K411 & K413, respectively, in the Left Relay Box (114E2015-10) from the 28 VDC Primary Bus			
FUEL PUMP CONTROL R FWD (AFT)	Tripped Crct Brkrs (CB 1049 & CB 1051)		5	Amps	All	>5 amps to same relay numbers as above but in the Right Relay Box, same pwr source		-10-2, pp 2-27/29, 53, 55/56 & 59 -23-4, p 10-116 -23-5, p F-147	12
Main Fuel Boost Pumps Power Overdraw - FWD LH (RH) FUEL PUMP	Tripped Crct Brkrs (CB 1027 & CB 1029)					>5 amps to the respective pump from the AC Primary Bus			
AFT LH (RH) FUEL PUMP	Tripped Crct Brkrs (CB 1025 & CB 1023)					>5 amps to the respective pump from the AC Secondary Bus			

Table: A5 Electrical (Cont'd)

Sheet No.: 8

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Auxiliary Fuel Boost Pump Relays (K409 & K415) Power Overdraw - AUX TANK FUEL PUMP CONT L FWD (AFT)	Tripped Crct Brkrs (CB 1067 & CB 1069)					>5 amps to relays K409 & K415, respectively, in the Left Relay Box (114E2015-10) from the 28 VDC Secondary Bus (also to L Low Aux Press light, DS1070, if either right side aux fuel boost pump sw is ON)			
AUX TANK FUEL PUMP CONT R FWD (AFT)	Tripped Crct Brkrs (CB 1063 & CB 1065)					>5 amps to same relay numbers as above but in the Right Relay Box, same pwr source. (Also to R Low Aux Press light, DS 1041, if either left side aux fuel boost pump switch is ON.)		-10-2, pp 2-27/29, 53, 55/56 & 59 -23-4, p 10-115 -23-5, p F-149	
Auxiliary Fuel Boost Pumps Pwr Overdraw - FWD LH (RH) AUX FUEL PUMP	Tripped Crct Brkrs (CB 1059 & CB 1055)		5	Amps	All	>5 amps to respective pump from the AC Secondary and Primary Busses, respectively			
AFT LH (RH) AUX FUEL PUMP	Tripped Crct Brkrs (CB 1061 & CB 1067)								
Crossfeed Fuel Valves and Crossfeed Fuel Lights Power Overdraw - FUEL CONT XFEED	Tripped Crct Brkr CB 1010					>5 amps to left or right valve/light system, as a function of the Crossfeed Fuel Valves switch, from the 28 VDC Primary Bus		-10-2, p 2-27/30, 56 & 59 -23-4, p 10-105 -23-5, pp F-153/155	13

Table: A5 Electrical (Cont'd)

Sheet No.: 9

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Emergency Eng. Fuel Shutoff Valve Power Overdraw - FUEL SHUTOFF ENG NO. 1 (2)	Tripped Crct Brkrs (CB 197 & CB 195)					>5 amps to respective valves and their associated indicator lights, from the 28 VDC Primary Bus		-10-2, pp 2-30, 56 & 59 -23-4, p 10-104 -23-5, pp F151-152	13
Fuel Quantity Indicator Power Overdraw - FUEL QTY IND	Tripped Crct Brkr CB 118					>5 amps to the gauge from the 115 VAC Primary Bus		-10-2, pp 2-31, 53, 56 & 59 -23-3, pp 8-87 & FO-24 -23-5, pp F-69	
Low Fuel (Thermistor Control) Unit Pwr Overdraw - FUEL CONT QTY	Tripped Crct Brkr CB 120					>5 amps to the control unit from the 28 VDC Primary Bus			
Transmission Oil Pressure Indicating Sys Pwr Overdraw - XMSN OIL IND PRESS	Tripped Crct Brkr (CB 119)		5	Amps	All	>5 amps to system from 115 VAC Primary Bus		-10-2, pp 2-41, 53 & 56 -23-3, p FO-22 -23-5, p F-53	
Transmission Oil Temperature Indicating Sys Pwr Overdraw - XMSN OIL IND TEMP	Tripped Crct Brkr (CB 106)					>5 amps to system from 115 VAC Primary Bus		-10-2, pp 2-42/43, 53 & 56 -23-3, pp 8-57 & 58 -23-5, p F-51	
Hydraulic Pressure Transmitter & Indicator Synchros Pwr Overdraw - PRESS IND HYD	Tripped Crct Brkr (CB 108)					>5 amps to units from the 26 VAC Instrument Bus		-10-2, pp 2-53 & 56 -23-3, pp 8-47 & 9-93/95 -23-5, pp F-40 & 49	

Table: A5 Electrical (Cont'd)

Sheet No.: 10

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Accessory and Utility Solenoid (L179), Thermal Switch (S711) & Air Cooler Solenoid Valve (L717) Power Overdraw - UTILITY HYD SYS	Tripped Crct Brkr (CB 175)		5	Amps	All	>5 amps to units from the Battery Bus		-10-2, pp 2-40, 56 & 58 -23-3, p FO-15 -23-5, pp F-83, 121 & 125	
Flight Control Hydraulic Boost Solenoids Pwr Overdraw - HYD BOOST CONT	Tripped Crct Brkr (CB 109)					>5 amps to solenoids from the 28 VDC Secondary Bus		-10-2, pp 2-40, 56 & 59 -23-3, p FO-14 -23-5, p F-49	
Pitch Stability Augmentation System Power Overdraw - SPEED TRIM DC	Tripped Crct Brkr (CB 103)					>5 amps to the centering spring & speed trim amplifier from the 28 VDC Secondary Bus		-10-2, pp 2-36/37, 56 & 59 -23-5, p F-41	
Differential Collective Pitch Trim Sys Pwr Overdraw - SPEED TRIM AC	Tripped Crct Brkr (CB 101)					>5 amps to the speed trim amplifier from the 115 VAC Secondary Bus			
#1 and #2 SAS Amplifiers DC Voltage Supply and Hydraulic Solenoid Valves Pwr Overdraw - NO. 1 (2) SAS DC	Tripped Crct Brkrs (CB 117 & CB 115)					>5 amps to systems from the 28 VDC Primary Bus		-10-2, pp 2-35, 52/56 & 59 -23-3, p 9-95 -23-5, p F-45	14

Table: A5 Electrical (Cont'd)

Sheet No.: 11

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
#1 and #2 SAS Amplifiers AC Voltage and Rate Gyros Pwr Overdraw - NO. 1 (2) SAS AC	Tripped Crct Brkrs (CB 113 & CB 111)		5	Amps	All	>5 amps to systems from the 115 VAC Primary Bus		-10-2, pp 2-35, 52/56 & 59 -23-3, p 9-95 -23-5, p F-45	
Centering Device Release Mechanisms Pwr Overdraw - CONT CTR	Tripped Crct Brkr (CB 105)		7			>5 amps to yaw magnetic brake & pitch and roll trim actuators from the 28 VDC Battery Bus		-10-2, pp 2-33, 56, 58 & 59 -23-3, p 9-95 -23-5, p F-48	15
Manually Commanded Cyclic Trim Actuators Pwr Overdraw - CYCLIC TRIM ACT AFT (FWD)	Tripped Crct Brkrs (CB 102 & CB104)					>7.5 amps to the respective actuators through the corresponding manual operation switches, from the 28 VDC Primary Bus		-10-2, pp 2-36/37, 56 & 59 -23-5, p F-41	
Caution Panel and/or Master Caution Lights, & Troop Jump Signal Light Dimming Relay (K110) Power Overdraw - CAUTION LGTS	Tripped Crct Brkr (CB 112)		5		Bright/ Dim sw at BRIGHT	>5 amps to system including negative fault sensed/ triggered caution capsule lamps, but excluding K110, from the 28 VDC Primary Bus		-10-2, pp 2-56 & 59 -23-3, pp 9-95, 98/99 & FO-28 -23-5, pp F-77, 161, 171 & 181	
					Brignt/ Dim sw at DIM	Same as above but including K110			
Pitot Tube Heater Pwr Overdraw - PITOT HEAT	Tripped Crct Brkr (CB 137)		5		All	>5 amps to heaters from the 115 VAC Secondary Bus		-10-2, pp 2-45, 53 & 56 -23-3, pp 8-30/31 & 36 -23-5, p F-73	

Table: A5 Electrical (Cont'd)

Sheet No.: 12

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Side Slip Port Heaters Power Overdraw - STATIC PORT HTR	Tripped Crct Brkr (CB 139)		7	Amps	All	>7.5 amps to heaters from the 115 VAC Secondary Bus		-10-2, pp 2-45, 53 & 56 -23-3, pp 8-30/31 & 36 -23-5, p F-73	
Pilot, Center & Copilot Wshld Temperature Controllers (A108, A110 & A112, resp.) and Anti-Ice Relays (K119, K102 & K121 respectively) Pwr Overdraw - WSHLD ANTI-ICE CONT PILOT (CTR, COPILOT)	Tripped Crct Brkrs (CB 149, CB 153 & CB 151)		5			>5 amps to the respective temperature controller & relay from the 28 VDC Secondary Bus, through the respective circuit breaker		-10-2, pp 2-45, 53, 55/56 & 59 -23-4, pp 12-1/4 -23-5, p F-79	
Pilot, Center & Copilot Windshield Heating Element Power Overdraw - WSHLD AI	Tripped Crct Brkrs (CB 155, CB 157 & CB 159)		25			>25 amps (CB 155 & CB 159) to the pilot and copilot windshield heating elements (respectively) from the 115 VAC Secondary Bus (phases A & C)			
			10			>10 amps (CB 157) to the center windshield heating element from the 115 VAC Secondary Bus (phase B)			

Table: A5 Electrical (Cont'd)

Sheet No.: 13

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Windshield Wiper Motor Pwr Overdraw - WSHLD WIPER	Tripped Crct Brkr (CB 170)		10			>10 amps to motor from the 28 VDC Secondary Bus		-10-2, pp 2-46, 56 & 59 -23-4, p 12-27 -23-5, p F-117	
Cockpit Utility Receptacles Pwr Overdraw - UTILITY REC PILOT (COPILOT)	Tripped Crct Brkrs (CB 168 & CB 166)					>15 amps to the respective unit from the 28 VDC Secondary Bus			
Cabin Utility Receptacles Pwr Overdraw - UTILITY RECEPTACLE LH FWD (AFT)	Tripped Crct Brkrs (CB 178 & CB 176)					>15 amps to the respective unit from the 28 VDC Secondary Bus		-10-2, pp 2-46, 53/55 & 59 -23-3, pp 9-7/11 & 45/46 -23-5, p F-114 & 129	
UTILITY RECEPTACLE RH FWD	Tripped Crct Brkr (CB 172)								
UT RECP RH AFT	Tripped Crct Brkr (CB 174)								
Missile Warmup Receptacles 1 & 2 Power Overdraw - MISSILE WARM UP #1 (2)	Tripped Crct Brkrs (CB 179 & CB 177)		15	Amps	All	>15 amps to the respective unit from the 208 VAC Auxiliary Bus & the 208 VAC Secondary Bus, respectively		-10-2, pp 2-47/48, 52, 53 & 55 -23-3, pp 9-48/49 -23-5, p F-127	
Strobex Blade Tracking Receptacle Pwr Overdraw - BLADE TCK	Tripped Crct Brkr (CB 1066)		5			>5 amps to outlet from the 28 VDC Secondary Bus		-10-2, p 2-48, 54 & 59 -23-5, pp F-130/131	

Table: A5 Electrical (Cont'd)

Sheet No.: I4

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Heater Blower Pwr Overdraw - BLOWER	Tripped Crct Brkr (CB 141)		15		All	>15 amps to the blower on any or all phases, from the 208 VAC Auxiliary Bus			
Heater System Relays (K137, K205, K207, K209, & K211), Temperature Controller, Thermostat, Fuel Control, Ignition and Master Fuel Valve Solenoid Pwr Overdraw - HEATER CONT	Tripped Crct Brkr (CB 143)		7	Amps	Heating Sw at VENT BLOWER ONLY	>7.5 amps to relay K137 from the 28 VDC Primary Bus		-10-2, pp 2-49, 52, 55/56 & 59 -23-4, p 13-7 -23-5, p F-77	
					Heating Sw at HEATER ON, heater running	>7.5 amps to all components. Same power source.			
					Heating Sw at HEATER ON, heater started but cycled off	>7.5 amps to all components except the Fuel Control solenoid valve. Same power source.			
					Heating Sw at HEATER ON, HEATER HOT caution light on	>7.5 amps to all relays except K137 and K205. Same power source.			

Table: A5 Electrical (Cont'd)

Sheet No.: 15

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	PARAMETER OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Right Aft Lndng Gear Swivel Lock, Power Steering Control Valve, Actuator and Control Box Pwr Overdraw - AFT WHEEL	Tripped Crct Brkr (CB 185)		7.5	Amps	Power Steering OFF	>7.5 amps to swivel lock manifold from the 28 VDC Primary Bus when AFT WHEELS switch position is changed		-10-2, pp 2-7, 54 & 59 -23-3, pp 7-253 -23-5, p F-128	
					Power Steering ON	>7.5 amps to power steering system. Same power source.			
Cargo Hook Control Relay (K407) and Release Valve Solenoid (L403) Pwr Overdraw - CARGO HOOK CONT	Tripped Crct Brkr (CB 180)		5		All	>5 amps to components from the 28 VDC Secondary Bus		-10-2, pp 2-71 & 4-25 -23-4, p 16-143 -23-5, p F-119	
Cargo Hook Emergency Release Valve Solenoid (L405) Power Overdraw - CARGO HOOK EMER	Tripped Crct Brkr (CB 182)					>5 amps to L405 from the 28 VDC Emergency Bus			
Winch Hydraulic Control Valve (L201), Brake Release Solenoid (L203) & Hoist Control Pwr Overdraw - HOIST CONT	Tripped Crct Brkr (CB 183)				Hoist Control sw at OFF	>5 amps to L203 from the 28 VDC Secondary Bus		-10-2, pp 2-56, 59 & 4-12 -23-4, p 14-4 -23-5, p F-115	
					Hoist Control sw at IN or OUT	>5 amps to L201. Same power source.			
Hoist Cable Cutter (L401) Pwr Overdraw - HOIST CUTTER	Tripped Crct Brkr (CB 181)		10			>10 amps to cutter from the 28 VDC Primary Bus			

Table: A5 Electrical (Cont'd)

Sheet No.: 16

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Position Lgts Pwr Overdraw - POS LTS	Tripped Crct Brkr (CB 140)		5	Amps	All	>5amps to system from the 28 VDC Secondary Bus		-10-2, pp 2-56, 59 & 61/62 -23-3, pp 9-67/68 -23-5, p F-103	
Anti-Collision Lights Power Overdraw - ANTI COLL LTS TOP (BOTTOM)	Tripped Crct Brkrs (CB 142 & CB 144)					>5 amps to each light through the respective brkr, from the 28 VDC Secondary Bus			
Formation Lgts and Control Pwr Overdraw - FORM LTS	Tripped Crct Brkr (CB 1053)					>5 amps to system from the 115 VAC Primary Bus		-10-2, pp 2-53, 55 & 62 -23-3, pp 9-83/84 -23-5, p F-102	
Pilot & Copilot Searchlgt Ctrl Motors & Relays Pwr Overdraw - SLT CONT PILOT (CO PILOT)	Tripped Crct Brkrs (CB 152 & CB 154)				Search-light control sw at L or R	>5 amps to rotation motor and applicable relay from the 28 VDC Secondary Bus		-10-2, pp 2-55/56, 59 & 63 -23-3, p 9-73 -23-5, p F-105	
					Search-light control sw at EXTEND	>5 amps to ext/ret motor and extend relay. Same power source.			
					Search-light control sw or overhead panel control sw at RETR	>5 amps to ext/ret motor & retract relay (plus rotation motor & right relay if light is being fully retracted). Same power source.			

Table: A5 Electrical (Cont'd)

Sheet No.: 17

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Pilot & Copilot Searchlight Lamp Power Overdraw - SL FIL PLT (COPLT)	Tripped Crct Brkrs (CB 148 & CB 150)		25	Amps	All	>25 amps to respective filament from the 28 VDC Secondary Bus		-10-2, pp 2-55/56, 59 & 63 -23-3, p 9-73 -23-5, p F-105	
Overhead Switch and Crct Brkr Panels and Dimming Rheostats Pwr Overdraw- OVRHD PNL LTS	Tripped Crct Brkr (CB 138)					>5 amps to system from the 28 VDC Primary Bus		-10-2, pp 2-56, 59 & 63 -23-3, p 9-63 -23-5, p F-101	
Pilot & Copilot Flight Instrument Lights, Center Section and Dimmer Rheostats Pwr Overdraw - INSTRUMENT LTS PILOT (COPILOT & CTR)	Tripped Crct Brkrs (CB 160, CB 134 & CB 136)		5			>5 amps to lighting system from the 28 VDC Primary Bus, through the respective breaker (except for the turn & slip and cruise guide indicators during an AC or DC Primary Bus failure. In that case the instruments receive power from the Secondary Cockpit Lights circuit breaker CB 162).		-10-2, pp 2-56, 59 & 63/64 -23-3, p 9-63 -23-5, p F-95/97	
Console Lights and Dimmer Rheostat Pwr Overdraw - CONSOLE LTS	Tripped Crct Brkr (CB 173)					>5 amps to system form the 28 VDC Primary Bus		-10-2, pp 2-56, 59 & 64 -23-3, p 9-62 -23-5, p F-98	

Table: A5 Electrical (Cont'd)

Sheet No.: 18

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	PARAMETER OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Cabin Dome and Utility Lights and Dimmer Rheostats Power Overdraw - COCKPIT LTS	Tripped Crct Brkr (CB 158)		5	Amps	All	>5 amps to operating systems from the 28 VDC Battery Bus		-10-2, pp 2-56, 59 & 64 -23-3, p 9-56 -23-5, p F-106	
Secondary Cockpit Lights and Dimmer Rheostats, Turn and Slip and Cruise Guide Indicator Lgts Pwr Overdraw - SECONDARY CKPT LTS	Tripped Crct Brkr (CB 162)				AC & DC Primary Busses on line	>5 amps to all lgt systems (except the turn & slip and cruise guide indicator lights) from the 29 VDC Battery Bus		-10-2, pp 2-56, 59 & 64 -23-3, pp 9-57/59 -23-5, p F-107	
					AC or DC Primary Bus off line	>5 amps to all light systems. Same power source.			
Cabin and Ramp Lights & Relays (K201 & K203), Jump Light Dimming Relay (K300) and Emergency Exit Lights Charge Pwr Overdraw - CABIN LTS	Tripped Crct Brkr (CB 156)		10		Cabin & Ramp Lts sw at Red	>10 amps to systems except white lights & K203 from the 28 VDC Battery Bus		-10-2, pp 2-54, 58 & 66 -23-3, p 9-60 -23-4, p 17-2 -23-5, pp F-109 & 113	
					Cabin & Ramp Lts sw at White	>10 amps to systems except red lights, K201 and K300. Same power source.			
Oil Level Check Lights Power Overdraw - OIL CHK LTS	Tripped Crct Brkr (CB 146)		5		All	>5 amps to operating lights from the 28 VDC Battery Bus		-10-2, pp 2-54, 58 & 67 -23-3, pp 9-65/66 -23-5, p F-104	
Engine Nacelle Work Lights Pwr Overdraw - ENG NAC LTS	Tripped Crct Brkr (CB 164)							-10-2, pp 2-54, 58 & 67 -23-3, p 9-64 -23-5, p F-112	

Table: A5 Electrical (Cont'd)

Sheet No.: 19

PARAMETER NAME-INDICATOR LABEL	INDICATOR				OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS	UNITS		CONDITION	CONDITION TYPE - DURATION		
Troop Jump Lgts Pwr Overdraw - TROOP ALARM JUMP LTS	Tripped Crct Brkr (CB 1004)		5	Amps	All	>5 amps to lights from the 28 VDC Battery Bus		-10-2, pp 2-18, 56 & 58 -23-3, pp 9-60/62 -23-5, p F-165	
Troop Jump Alarm Bells Power Overdraw - TROOP ALARM BELL	Tripped Crct Brkr (CB 1002)					>5 amps to bells from the 28 VDC Battery Bus			
Fire Extinguisher Control Relay (K127) & Fire Bottle Valves Supply Pwr Overdraw - FIRE EXT	Tripped Crct Brkr (CB 1000)		10			>10 amps to relay and all activated valves from the 28 VDC Primary Bus			
Fire Bottle #1 (2) Individual Valve Power Overdraw - BOTTLE NO. 1 FWD (AFT) VALVE	Tripped Crct Brkrs (CB 706 & CB 702)		5			>5 amps to the activated valve, through the FIRE EXT circuit brkr (CB 1000)		-10-2, pp 2-16/18, 56 & 59 -23-4, p 12-14 -23-5, pp F-157 & 163	16
BOTTLE NO. 2 FWD (AFT) VALVE	Tripped Crct Brkrs (CB 704 & CB 700)								
Engine #1 (2) Fire Detection System Control Unit, Sensing Element and T Handle Lgts Pwr Overdraw - FIRE DET ENG NO. 1 (2)	Tripped Crct Brkrs (CB 1008 & CB 1006)		5			>5 amps to respective system from the 115 VAC Primary Bus		-10-2, pp 2-16, 53 & 56 -23-4, p 12-8 -23-5, pp F-156/157	

Table: A5 Electrical (Cont'd)

Sheet No.: 20

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	PARAMETER OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
Self Tuning Dynamic Absorber System Pwr Overdraw - VIBRATION ABSORBERS LEFT (CTR & RIGHT)	Tripped Crct Brkrs (CB 1083, CB 1085 & CB 1081)		7.5			>7.5 amps to the respective absorber from the 115 VAC Primary Bus		-10-2, pp 2-10, 52 & 55 -23-1, p 2-188 -23-5, p F-132	
APU Relays K1-K6, No. 1 & 2 Flight Control Pump Solenoids, APU Fuel Boost Pump, APU Start Valve Solenoid, APU Start Fuel Valve Solenoid, APU Main Fuel Valve Solenoid, APU Fuel Valve Solenoid, APU Motor Valve Solenoid, APU Igniter, APU Warning Lights and APU Hour Meter Power Overdraw - APU	Tripped Crct Brkr (CB 186)		10	Amps	APU sw at STOP, GND APU-AGB sw at NORM	>10 amps to the press to test warn. lgts (norm. out) from the 28 VDC Battery Bus		-10-2, pp 2-56, 58, 60 & 61 -23-4, pp 15-1/2 & FO-42 -23-5, pp F-123/125	17
					APU sw at STOP, GND APU-AGB sw at START	>10 amps to systems above & No. 1 Flgt Cntrl Valve Solenoid. Same power source. (See note.)			
					APU sw at APU, APU not running	>10 amps to OVSP & HIGH EXH TEMP warn. lgts & LOW OIL PRESS warn. lgt if lit (norm. out) Same power source.			
					APU sw at APU, APU running	>10 amps to relays K3, K4, K5, the Main Fuel Valve & APU Fuel Valve solenoids, the APU Fuel Boost Pump & the APU Hour Meter. Same power source.			
					APU sw at START, APU <90%, Fuel pressure <110 psi	>10 amps to all components except the warn. lgts (assumed off), main fuel valve solenoid & the igniter. Same power source.			
					APU sw at START, APU <90%, Fuel pressure >110 psi	>10 amps to all components except the warn. lgts (assumed off) & relay K1. Same power source.			

Table: A5 (Electrical - Cont'd) Sheet No.: 21

NOTES:

1. Sensors are step down current transformers, contained in the respective generator control panel (A517 & 514 - note that throughout this table, a 114ES249 series control panel is assumed in use). The overvoltage time delay decreases linearly with increased output voltage (0.115 seconds for 180 vac). Normal voltage phase to ground is 120 vac (regulated to 115 vac) and phase to phase is 208 vac (regulated to 200 vac). The under frequency protection circuit reconnects the generator to the load if the output frequency rises back above 360 Hz. The undervoltage protection circuit reconnects the generator to the load if the 3 phase average voltage climbs to 104 vac, unless a lockout has been applied by the underfrequency circuit. The feeder protection senses current differences between the phase feeder and ground return lines.

2. Sensors are transformer (T213 & T215) which electromagnetically couple the loadmeters to the B phase power leads of generators #1 and #2. The units on the loadmeters are fractional loads, where 1.0 is 100% of the generator continuous load rating. The cautionary conditions were deduced on the basis that the continuous load should not exceed 100% of the rated load with the generator on line. If the generator is off line, the only load possible should be B phase sensing at the generator control panel.

3. Sensor is a Phase Sequence Network which checks the external power for proper phase sequence and activates relay K113 which delivers power (through contacts of relays K109 & K111) to the Gen. No. 1 Ext Pwr Relay (K101). K101 then connects the external power to the AC Primary Bus, and through a separate set of contacts, grounds the caution panel sensing lead which lights the light.

4. Sensors are low impedance shunts which produce a voltage sensed and displayed by the millivoltmeter type indicators. Loadmeter units are fractional loads like the AC loadmeters, where 1.0 load is 200 amperes (full rated load) and 300 amperes is a 1.5 load.

5. Sensors are REV CUR CO. Relays K128 and K126 respectively, which trip the corresponding XFMR-RECT FAILURE Relays (K118 & K120). These relays have contacts which ground the caution panel sensing lead which actuates the proper light.

6. Sensor is a blocking diode (CR 100, TM 47) which, for external voltage of the correct polarity, provides a current path for the coils of EXT PWR CONT Relay (K122). A pair of contacts for this relay closes a path to ground for the caution panel sensing lead which operates the light.

7. There are two circuit breakers for each of the three inter-bus feeder lines. Hence CB 1031 and C199 protect the same line and so forth for the other two lines and four breakers. The A PH FDR breakers are on the AC circuit Breaker Box and other breakers are on the overhead breaker panel.

8. Arrangement similar to that described in Note 7 above.

9. Power is supplied to the brake when the trigger switch is not engaged.

10. A caution on page 2-21 of the Operator's Manual notes that these circuit breakers must be in, otherwise the anti-ice will be on, degrading engine performance.

11. Note that these breakers are not shown on the typical overhead breaker panel illustrations of p 2-56 (Operator's Manual) and pages 9-93/95 of TM 55-1520-227-23-3.

12. The boost pumps are AC powered, via relays which are actuated by fuel boost pump switches in the overhead fuel panel. These switches route 28 vdc power to the relays. Specific signal routing is shown in the -23-5 reference figures. The indicator lights are not in the cockpit.

13. The valves are electrically actuated by the No. 1 (2) Engine Emergency T-Handle switches, S140 & S187. The indicator lights are not in the cockpit.

14. Power is routed to the amplifiers via the SAS Emergency Release Switch.

15. Power is supplied to the actuators/brake when the release button is engaged.

16. These circuit breakers are on a box located at station 534, on the overhead structure.

17. Since the position of the GND APU-AGB switch is not included in all of the operating modes listed, it should be noted that anytime the switch is in the start position, the additional load of the No. 1 Flight Control Valve solenoid is applied through the circuit breaker.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A6

SUBSYSTEM: Miscellaneous

Sheet No.: 1

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 3)
Longitudinal Cyclic Trim Actuator Position - CYCLIC TRIM ACT-FWD (AFT)	Circular Dials (2)	0-160	--	KTS	0-60 KIAS	≤60	Normal - continuous	-10-2, pp 2-38, 5-17 & 9-14 -23-3, p 8-43 -23-4, p 11-230 -23-5, p F-41	1
						>60	Cautionary - unspecified		
					60-120 KIAS (see note)	≤60	Cautionary - unspecified		
						>60	Normal - continuous		
SAS Amplifier Power Interruption or Disengagement - NO. 1 (2) SAS OFF	Caution Lgts (2)	--	Amber	--	All	1. AC or DC power failure to amplifiers 2. <2000 psi hydraulic pressure to the No. 1 or No. 2 hydraulic sys. respectively	Cautionary - unspecified	-10-2, pp 2-36, , 71, 5-18 & J-14 -23-3, pp 9-98/99 & FO-14 -23-5, pp F-45 & 49	2
						DC power interrupted by EMER SAS REL switch	Advisory - unspecified		
						1. SAS sw moved to different positions 2. HYD BST sw moved to different positions	Normal - transient		
Heater Output Temperature - HEATER HOT	Caution Lgt	--	Amber	°C	Heater on	≥177 (see note)	Cautionary - unspecified	-10-2, pp 2-49 & 71 -23-4, pp 13-1 & 7 -23-5, p F-77	3
					Heater off due to shutdown	1. ≥177 & heating sw at HEATER ON, or 2. <177 & HEATER START button not pushed or heating sw at HEATER ON			

Table: A6 (Miscellaneous - Cont'd)

Sheet No.: 2

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	PARAMETER OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 2)
Right Aft Steerable Landing Gear Swivel Angle - WHEEL DEPHASED	Caution Lgt	--	Amber	deg	Lft turn (clock-wise swivel)	≥62.5	Cautionary - unspecified	-10-2, pp 2-7 & 70 -23-3, pp 7-253/254 & FO-19 -23-5, p F-128	4
					Rt turn (ccw swivel)	≥91			
Parking Brake Valve Plunger Position - PARK BRAKE ON	Caution Lgt	--	Amber	--	Air-craft on ground, no taxi	Plunger position is such as will trap fluid for parking brake actuation	Advisory - unspecified	-10-2, pp 2-7/9 & 70 -23-3, pp 7-268 & 277 -23-5, pp F-128	5
					Air-craft ground taxiing or in flight		Cautionary - unspecified		
Cargo Hook Position - CARGO HOOK OPEN	Caution Lgt	--	Amber	--	All	Cargo hook is in OPEN position	Cautionary - unspecified	-10-2, pp 2-71 & 4-21/25 -23-4, pp 16-142/144 -23-5, p F-119	6

Table: A6 (Miscellaneous - Cont'd) Sheet No.: 3

NOTES:

1. Sensors are (most likely) variable resistors which are built into both the forward pylon actuator and aft pylon actuator. The wiper of the resistor is mechanically driven by the actuator's dc servo motor and the resistor is electrically connected to the speed trim amplifier which in turn supplies the drive signal for the indicators. For operations at airspeeds above 60 KTS with the indicator showing 0-60 KTS, the maximum allowable airspeed is obtained from Figure 5-11, p 5-17 of the Operator's Manual.

2. Sensors are the No. 1 and No. 2 SAS amplifiers themselves, sensing vac, vdc, and No. 1 and No. 2 hydraulic system pressures. The activation of the capsule segments is accomplished by applying a ground to the appropriate line running to the caution panel. In addition the EMER SAS REL switch applies a ground to both of these lines when in the RELEASE position. Power to the capsule segments is most likely supplied by the DC Primary Bus through the CAUTION LTS circuit breaker on the overhead panel. Airspeed limit with one SAS on line is V_{ne} or 120 KTS (if lower). Airpseed limits with both SAS off line below 120 KTS is V_{ne}, if $V_{ne} \leq 120$ KTS.

3. Sensor is a thermoswitch (A209) which opens at 177°C removing power from relay K209 which shuts down the fuel control and ignition circuits while completing the grounding circuit for the caution light. The requirements for lighting the light are that K209 be deenergized and relay K205 be energized, which is accomplished by leaving the heating switch in the HEATER ON position.

4. Sensor is a cam actuated microswitch which simultaneously disables the power steering while turning on the caution light. The limits used are explained on the referenced page 7-253 and differ from those given in the Operator's Manual, these latter, being mean angular swivel values for the power steering tolerance zones. The disabling limits which are used in this A6 table are the wheel "out-of-zone" buffer zone extreme limits.

5. Sensor is most likely a position sensitive switch, linked to the parking brake valve pressure actuated plunger. Thus the switch may be indirectly referred to as pressure sensitive, although it is unclear whether loss of brake pressure would release the plunger and result in a state change of the switch and parking brake lever. Caution light activation is through grounding of the caution panel sensing lead.

6. Sensors are two position sensing switches. Switch S403 senses the hook rotating cam position, as operated by the manual emergency release. Switch S405 senses the hook actuating cylinder position, as operated by the normal hydraulic or emergency air release modes. Either switch provides a grounding path for the caution panel sensing lead.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A7

SUBSYSTEM: Auxiliary Power Unit (APU: T-62T-2A Type)

Sheet No.: 1

PARAMETER NAME-INDICATOR LABEL	INDICATOR TYPE	INDICATOR RANGE	INDICATOR MARKINGS	INDICATOR UNITS	OPERATING MODE	PARAMETER CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 2)
Turbine Speed - APU TACHOMETER	Circular Dial	0-110	--	%	APU sw at START	90	Maximum (release APU switch) - transient	-10-2, pp 2-60/61, 5-1, 8-5/6.1 -23-4, pp 15-1/3, 13 & FO-42 -23-5, p F-123/125	1
					APU sw at APU	90-98	Cautionary - transient		
						98-106	Normal - continuous (5 to 15 seconds after start initiated)		
						106-110	Cautionary - transient		
						≥110	Maximum - transient		
OVSP	Warning Lgt (Press to Test)	--	Red	%	APU is on	≥110	Maximum (overspeed) - unspecified (see note)		2
Exhaust Gas Temperature - HIGH EXH TEMP	Warning Lgt (Press to Test)	--	Red	°C	APU is on	≥(577-582)	Maximum (overtemp) - unspecified		3
Low Oil Pressure - LOW OIL PRESS	Warning Lgt (Press to Test)	--	Red	psi	APU is on	≤(5-7)	Minimum - unspecified		4

AD-A117 919 GENERAL ELECTRIC CO BINGHAMTON N Y AIRCRAFT EQUIPMENT DIV F/G 1/3
NON-COMPLEX ITEM DEVELOPMENT SPECIFICATION FOR A FEASIBILITY MO--ETC(U)
JUN 81 DAAK80-79-C-0270
UNCLASSIFIED ACS-12 USAAVRADCOM-TR-79-0270-4 NL

Table: A7 (APU - Cont'd) Sheet No.: 2

NOTES:

1. Sensor is a tachometer generator, mounted on and driven by the APU speed switch. The 3 phase AC output voltage is proportional to the APU turbine speed. The APU speed should stabilize in the 98-106% range 5-15 seconds after start is initiated.

2. Sensor is an overspeed switch which deenergizes the overspeed switch relay (K5), thereby simultaneously turning on the light and removing power from the APU main fuel valve solenoid, which shuts down the APU. The overspeed duration is unspecified, since shutdown commences simultaneously with the warning light activation. However, should the light activate and the APU not shut down, the 5 second overspeed limit should be observed and the APU should be shut down manually. The light will also illuminate when the APU is shut down and the switch is in the APU position.

3. Sensor is a thermoswitch which deenergizes the high exhaust gas temperature relay (K4) thereby simultaneously turning on the light and shutting down the APU as described in Note 2 above. The first page reference says the switching threshold is 582° ± 6°C for a T62-T-2A1 type APU, but the page 15-1 reference lists two thresholds: the one which is used on sheet 1 of this table plus a 560°-577°C range for an unspecified type of APU. The light is also on when the APU is not running and the switch is in the APU position.

4. Sensor is a pressure switch which deenergizes the low oil pressure relay (K3) thereby simultaneously turning on the light and shutting down the APU in the manner described in Note 2 above. The light does not come on if the APU is shut down and the switch is in the APU position.

Appendix II

FAULT ALGORITHMS

Fault: ROTOR RPM

Fault Type: Warning

Fault 1 = {[GRD OPER·(RRPM.LT.RPMLM1)]+[PWR FLGHT·(RRPM.LT.RPMLM2)]+
[AROTA·[(RRPM.LT.RPMLM2)+(RRPM.GT.RPMLM3)]]}·ENABLE

Fault 2 = [(RRPM.GT.RPMLM4)+(RRPM.LT.RPMLM5)]·PWR FLGHT·ENABLE

Fault 3 = (RRPM.GT.RPMLM5)·(RRPM.LT.RPMLM7)·PWR FLGHT·ENABLE

Fault 4 = (RRPM.GT.RPMLM6)·AROTA·ENABLE

Fault 5 = (RRPM.GT.RPMLM7)·PWR FLGHT·ENABLE

Where:

RPMLM1 = 214 RPM
RPMLM2 = 232 RPM
RPMLM3 = 261 RPM
RPMLM4 = 250 RPM
RPMLM5 = 255 RPM
RPMLM6 = 265 RPM
RPMLM7 = 262.5 RPM

Fault: ROTOR RPM Time Out Faults (CLK=CLOCK)

Fault Type: Warning

Fault 1T = (RTRCLK1.GE.T1)·$\overline{\text{(Fault 2T)}}$

Fault 2T = (RTRCLK2,GE.T2)

Where:

RTRCLK1 Starts/Runs if Rotor Fault 2 is detected. It is 0 otherwise.
RTRCLK2 Starts/Runs if Rotor Fault 3 is detected. It is 0 otherwise.
T1 (min) = 5
T2 (sec) = 5

Fault: ENG 1 and 2 Flameout/Fail

Fault Type: Warning

Fault = (ENG 1 Flameout/Fail Fault)·(ENG 2 Flameout/Fail Fault)·(Enable)

Fault: ENG 1 Flameout/Fail

Fault Type: Warning

Fault = {[(E1CLVR,FLGHT)·(E1N1.LT.N1LIM4)·(PTIT1.LT.TMPLM1)·(TORQ1.LT.TRQLM1)]+
[(E1CLVR,GRND)·(E1N1.LT.N1LIM5)·(PTIT1.LT.TMPLM2)·(TORQ1.LT.TRQLM2)]+
[(E1CLVR,OTDTNT)·(E1N1.LT.N1LIM6)·(PTIT1.LT.TMPLM3)·(TORQ1.LT.TRQLM3)]}
·ENABLE·$\overline{\text{ENG1 STRT}}$

Where:

N1LIM4 = 70%	TMPLM1 = 400°C	TRQLM1 = 10%
N1LIM5 = 65%	TMPLM2 = 350°C	TRQLM2 = .5%
N1LIM6 = 60%	TMPLM3 = 399°C	TRQLM3 = .5%

Fault: ENG 2 Flameout/Fail

Fault Type: Warning

Fault = {[(E2CLVR,FLGHT)·(E2N1.LT.N1LIM4)·(PTIT2.LT.TMPLM1)·(TORQ2.LT.TRQLM1)]+
[(E2CLVR,GRND)·(E2N1.LT.N1LIM5)·(PTIT2.LT.TMPLM2)·(TORQ2.LT.TQLM2)]+
[(E2CLVR,OTDTNT)·(E2N1.LT.N1LIM6)·(PTIT2.LT.TMPLM3)·(TORQ2.LT.TRQL)]}
·ENABLE·$\overline{\text{ENG2 STRT}}$

Where:

N1LIM4 = 70%	TMPLM1 = 400'C	TRQLM1 = 10%
N1LIM5 = 65%	TMPLM2 = 350'C	TRQLM2 = .5%
N1LIM6 = 60%	TMPLM3 = 399'C	TRQLM3 = .5%

Fault: PTIT 1/2 (Power Turbine Inlet Temperature)

Fault Type: Caution/Precaution

Fault 1 = {[ENG1/2 STRT·(PTIT1/2.GT.PTITL1)]+[ENG1/2 SDWN·(PTIT1/2.GT.PTITL3)]+
[$\overline{\text{ENG1/2 STRT}}$·$\overline{\text{ENG1/2 SDWN}}$·(PTIT1/2.LT.PTITL2)]}
·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 2 = {[ENG1/2 SDWN·(PTIT1/2.GE.PTITL4)]+(PTIT1/2.GT.PTITL5)}
·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 3 = {$\overline{\text{ENG1/2 STRT}}$·$\overline{\text{ENG1/2 SDWN}}$·[(PTIT1/2.GE.PTITL6)+(PTIT1/2.LT.PTITL7)]}
·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 4 = {$\overline{\text{ENG1/2 STRT}}$·$\overline{\text{ENG1/2 SDWN}}$·[(PTIT1/2.LT.PTITL8)+(PTIT1/2.GE.PTITL7)]}
·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 5 = {$\overline{\text{ENG1/2 STRT}}$·$\overline{\text{ENG1/2 SDWN}}$·[(PTIT1/2.GE.PTITL8)]}
·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Where:

PTITL1 = 788°C
PTITL2 = 399°C
PTITL3 = 260°C
PTITL4 = 350°C
PTITL5 = 927°C
PTITL6 = 770°C
PTITL7 = 810°C
PTITL8 = 860°C

Fault: PTIT 1/2 Time Out Faults (CLK = CLOCK)

Fault Type: Caution/Precaution

Fault 1T = (PTIT1CLK1.GE.T3)

Fault 2T = (PTIT2CLK1.GE.T4)

Fault 3T = (PTIT1CLK2.GE.T5)·($\overline{\text{FAULT 5T}}$)

Fault 4T = (PTIT2CLK2.GE.T5)·($\overline{\text{FAULT 6T}}$)

Fault 5T = (PTIT1CLK3.GE.T6)·($\overline{\text{FAULT 7T}}$)

Fault 6T = (PTIT2CLK3.GE.T6)·($\overline{\text{FAULT 8T}}$)

Fault 7T = (PTIT1CLK4.GE.T7)

Fault 8T = (PTIT2CLK4.GE.T7)

Where:

PTIT1CLK1 Starts/Runs if [ENABLE·(ENG1 STRT)·(PTIT1.GE.PTITL1)·
(PTIT1.LT.PTITL5)] is True. Otherwise it is 0.
PTIT2CLK1 Starts/Runs if [ENABLE·(ENG2 STRT)·(PTIT2.GE.PTITL1)]·
(PTIT2.LT.PTITL5)] is True. Otherwise it is 0.
PTIT1(2)CLK2 Starts/Runs if PTIT1(2) Fault 3 is detected. It is 0 otherwise.
PTIT1(2)CLK3 Starts/Runs if PTIT1(2) Fault 4 is detected. It is 0 otherwise.
PTIT1(2)CLK4 Starts/Runs if PTIT1(2) Fault 5 is detected. It is 0 otherwise.

T3 (sec) = (927 - PTIT1)/27.8
T4 (sec) = (927 - PTIT2)/27.8
T5 (min) = 30
T6 (min) = 10
T7 (sec) = 2

Fault: TORQUE 1/2

Fault Type: Caution/Precaution

Fault 1 = [SNGENG·(TORQ1/2.GT.TMAX1)·(TORQ1/2.LE.TMAX2)]·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 2 = [SNGENG·(TORQ1/2.GT.TMAX2)·(TORQ1/2.LE.TMAX3)]·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 3 = [SNGENG·(TORQ1/2.GT.TMAX3)·(TORQ1/2.LE.TMAX4)]·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 4 = [SNGENG·(TORQ1/2.GT.TMAX4)·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 5 = [DLENG·(TORQ1/2.GT.TMAX5)·(TORQ1/2.LE.TMAX3)]·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 6 = [DLENG·(TORQ1/2.GT.TMAX3)]·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Where:

SNGENG = (ENG1 FAIL FAULT $\oplus$ ENG2 FAIL FAULT)+[(E1N1.GT.N1L1M4)·(E2N1.LT.N1L1M4)]+[(E1N1.LT.N1L1M4)·(E2N1.GT.N1L1M4)]= Single Engine

DLENG = $\overline{\text{SNGENG}}$ = Dual Engine

TMAX1 = 85% if RRPM.GT.245; TMAX1 = 91% if RRPM.LT.230. Otherwise, TMAX1 = -.4(RRPM)+183 (See Appendix I)

TMAX2 = 97% if RRPM.GT.245; TMAX2 = 100% if RRPM.LT.235. Otherwise, TMAX2 = -.3(RRPM)+170.5 (See Appendix I)

TMAX3 = 100%

TMAX4 = 138%

TMAX5 = 78%

N1L1M = 70%

Fault: TORQUE 1/2 Time Out Faults (CLK = CLOCK)

Fault Type: Caution/Precaution

Fault 1T = (TQ1CLK1.GE.T5)·$\overline{\text{(FAULT 3T)}}$

Fault 2T = (TQ2CLK1.GE.T5)·$\overline{\text{(FAULT 4T)}}$

Fault 3T = (TQ1CLK2.GE.T6)·$\overline{\text{(FAULT 5T)}}$

Fault 4T = (TQ2CLK2.GE.T6)·$\overline{\text{(FAULT 6T)}}$

Fault 5T = (TQ1CLK3.GE.T8)

Fault 6T = (TQ2CLK3.GE.T8)

Where:

TQ1(2)CLK1 Starts/Runs if Torque 1(2) Fault 1 is detected. It is 0 otherwise.
TQ1(2)CLK2 Starts/Runs if Torque 1(2) Fault 2 is detected. It is 0 otherwise.
TQ1(2)CLK3 Starts/Runs if either Torque 1(2) Fault 3 or Fault 5 is detected.
It is 0 otherwise.
T5 (min) = 30
T6 (min) = 10
T8 (sec) = 10

Fault: N1 1/2 (Gas Producer Speed)

Fault Type: Caution/Precautions

Fault 1 = {(E1/2 CLVR,GRND)·[[E1/2N1.GT.N1LIM7]+[E1/2N1.LT.N1LIM6]]} +
{(E1/2 CLVR,FLGHT)·[[E1/2N1.LT.N1LIM5]+[E1/2N1.GT.N1LIM8]]}·
ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Fault 2 = [E1/2N1.GT.N1LIM9]·ENABLE·$\overline{\text{ENG1/2 FAIL FAULT}}$

Where:

N1LIM7 = 63%
N1LIM8 = 103%
N1LIM9 = 103%

Fault: ENG 1 OIL PRESSURE LIMIT

Fault Type: Caution/Precaution

Fault 1 = {[(E1N1.GE.N1LIM1)·(E1N1.LT.N1LIM2)·[(OLP1.LT.OLLIM1)+
(OLP1.GT.OLLIM2)]]+[(E1N1.GE.N1LIM2)·(E1N1.LT.N1LIM3)·
[(OLP1.LT.OLLIM3)+(OLP1.GT.OLLIM4)]]+[(E1N1.GE.N1LIM3)·
[(OLP1.LT.OLLIM4)+(OLP1.GT.OLLIM5)]]·}
ENABLE·$\overline{\text{ENG1 FAIL FAULT}}$

Fault 2 = (OLP1.GE.OLLIM2)·ENABLE·ENG1 FAIL FAULT

Where:

OLLIM1 = 20 psi N1LIM1 = 45%
OLLIM2 = 110 psi N1LIM2 = 70%
OLLIM3 = 35 psi N1LIM3 = 95%
OLLIM4 = 50 psi
OLLIM5 = 90 psi

Fault: ENG 2 OIL PRESSURE LIMIT

Fault Type: Caution/Precaution

Fault 1 = {[(E2N1.GE.N1LIM1)·(E2N1.LT.N1LIM2)·[(OLP2.LT.OLLIM1)+(OLP2.GT.OLLIM2)]]+[(E2N1.GE.N1LIM2)·(E2N1.LT.N1LIM3)·[(OLP2.LT.OLLIM3)+(OLP2.GT.OLLIM4)]]+[(E2N1.GE.N1LIM3)·[(OLP2.LT.OLLIM4)+(OLP2.GT.OLLIM5)]]} ·ENABLE·$\overline{\text{ENG2 FAIL FAULT}}$

Fault 2 = (OLP2.GE.OLLIM2)·ENABLE·$\overline{\text{ENG2 FAIL FAULT}}$

Where:

OLLIM1 = 20 psi N1LIM1 = 45%
OLLIM2 = 110 psi N1LIM2 = 70%
OLLIM3 = 35 psi N1LIM3 = 95%
OLLIM4 = 50 psi
O11IM5 = 90 psi

Fault: ENG 1/2 OIL TEMPERATURE LIMIT

Fault Type: Caution/Precaution

Fault = (OLT1.GE.OLTMPL)·ENABLE·$\overline{\text{ENG1 FAIL FAULT}}$
Fault = (OLT2.GE.OLTMPL)·ENABLE·$\overline{\text{ENG2 FAIL FAULT}}$

Where:

OLTMPL = 138'C

Fault: ENGINE 1/2 CHIP DETECTED

Fault Type: Caution/Precaution

Fault = E1CHIP·ENABLE
Fault = E2CHIP·ENABLE

Note: This fault shall cause the appropriate "*" symbol to appear in Format 2 as specified in 3.2.1.2.1.2.

Fault: ENGINE 1/2 OIL LEVEL LIMIT

Fault Type: Caution/Precaution

Fault = E1OLVL·ENABLE
Fault = E2OLVL·ENABLE

Note: This fault shall cause the appropriate "QTY" word to appear in the Format 2 display as specified in 3.2.1.2.1.2.

Fault: ENG 1/2 CONDITION LEVER OUT OF DETENT

Fault Type: Caution/Precaution

Fault = (E1CLVR,OTDTNT)·ENABLE·$\overline{\text{ENG1 FAIL FAULT}}$

Fault = (E2CLVR,OTDTNT)·ENABLE·$\overline{\text{ENG2 FAIL FAULT}}$

Note: This fault shall cause the appropriate "CTL" word to appear in the Format 2 display, as specified in Section 3.2.1.2.1.2.

DEFINITIONS

RRPM	=	Rotor RPM (Table I)
E1N1	=	Eng 1 N1 (Table I)
E2N1	=	Eng 2 N1 (Table I)
TORQ1	=	Eng 1 Torque (Table I)
TORQ2	=	Eng 2 Torque (Table I)
E1CLVR,FLGHT	=	Eng 1 Throttle-Fly (Table II - Logic State 1)
E2CLVR,FLGHT	=	ENG 2 Throttle-Fly (Table II - Logic State 1)
GRNDCS	=	Ground Contact (Table II - Logic State 1)
ENABLE	=	Faults Enable (Table II - Logic State 1)
.LT.	=	Less Than
.LE.	=	Less Than or Equal To
.GT.	=	Greater Than
.GE.	=	Greater Than or Equal To
AROTA	=	(TORQ1.LT.40%)·(TORQ2.LT.40%)·$\overline{\text{(GRNDCS)}}$ = Autorotation
GRD OPER	=	[(E1CLVR,FLGHT)·(E1N1.GE.65%)+ (E2CLVR,FLGHT)·(E2N1.GE.65%)]· GRNDCS = Ground Operations
PWR FLGHT	=	$\overline{\text{AROTA}}$·$\overline{\text{GRD OPER}}$
PTIT1	=	Eng 1 TGT (Table I)
PTIT2	=	Eng 2 TGT (Table I)
E1CLVR,GRND	=	Eng 1 Throttle - Ground (Table II - Logic State 1)
E2CLVR,GRND	=	Eng 2 Throttle - Ground (Table II - Logic State 1)
E1CLVR,OTDTNT	=	(E1CLVR,FLGHT)·(E1CLVR,GRND) = Eng 1 Throttle Out of Detent
E2CLVR,OTDTNT	=	(E2CLVR,FLGHT)·(E2CLVR,GRND) = Eng 2 Throttle Out of Detent
Eng 1 Start Fuel	=	FSRT1 (Table II - Logic State 1)
Eng 2 Start Fuel	=	FSRT2 (Table II - Logic State 1)
Eng 1 Ignition	=	IGNT1 (Table II - Logic State 1)
Eng 2 Ignition	=	IGNT2 (Table II - Logic State 1)
Eng 1 Starter	=	STRTR1 (Table II - Logic State 1)
Eng 2 Starter	=	STRTR2 (Table II - Logic State 1)
Eng 1 STRT	=	(FSRT1·IGNT1·STRTR1) = Eng 1 Starting

DEFINITIONS (Cont)

Eng 2 STRT	=	(FSRT2·IGNT2·STRTR2) = Eng 2 Starting
Eng 1 SDWN	=	$(\overline{\text{E1CLVR,FLGHT}})\cdot(\overline{\text{E1CLVR,GRND}})$ = Eng 1 Shut Down
Eng 2 SDWN	=	$(\overline{\text{E2CLVR,FLGHT}})\cdot(\overline{\text{E2CLVR,GRND}})$ = Eng 2 Shut Down
OLP1	=	Eng 1 Oil Press (Table I)
OLP2	=	Eng 2 Oil Press (Table I)
OLT1	=	Eng 1 Oil Temp (Table I)
OLT2	=	Eng 2 Oil Temp (Table I)
E1OLVL	=	Eng 1 Oil Low (Table II - Logic State 1)
E2OLVL	=	Eng 2 Oil Low (Table II - Logic State 1)
E1CHIP	=	Eng 1 Chip (Table II - Logic State 1)
E2CHIP	=	Eng 2 Chip (Table II - Logic State 1)

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